This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

Google™ books

https://books.google.com

QE
261
A4
1924

UC-NRLF
B 3 491 872

EXCHANGE
OCT 12 1925

Summary of Progress *of the* GEOLOGICAL SURVEY OF GREAT BRITAIN *and the* Museum of Practical Geology for the Year 1924

LONDON:
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased in the manner indicated on
the last page of this wrapper
1925
Price 2s. 6d. *Net*

Digitized by Google

EXCHANGE

EARTH
SCIENCES
LIBRARY

Digitized by Google

Digitized by Google

Digitized by Google

UNIV. OF

Department of Scientific and Industrial Research

Summary of Progress

of the

Geological Survey of Great Britain

and the

Museum of Practical Geology

for the Year 1924

With Report of the
Geological Survey Board and
Report of the Director

London :
Printed under the Authority of His Majesty's
Stationery Office
1925
Price 2s. 6d. Net

Digitized by Google

GE261
A4
1924

GEOLOGICAL SURVEY BOARD

EARTH SCIENCES LIBRARY

Sir Francis G. Ogilvie, C.B., LL.D., *Chairman.*
Professor W. S. Boulton, D.Sc., F.G.S.
Sir John Cadman, K.C.M.G., D.Sc.
Mr. I. G. Gibbon, C.B.E.
Professor J. W. Gregory, F.R.S.
Mr. C. S. Hurst, O.B.E.
Professor P. F. Kendall, M.Sc., F.R.S.
Mr. Frank Merricks, C.B.E., A.R.S.M
Sir Thomas Middleton, K.B.E., C.B.
Professor W. W. Watts, F.R.S.

Department of Scientific and Industrial Research,
16, Old Queen Street,
Westminster, London, S.W. 1.

EXCHANGE

Digitized by Google

UNIV. OF CALIFORNIA

CONTENTS

PAGE

REPORT OF THE GEOLOGICAL SURVEY BOARD FOR 1924 .. 1

REPORT OF THE DIRECTOR OF THE GEOLOGICAL SURVEY AND MUSEUM FOR 1924 7

SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY AND MUSEUM FOR 1924 :—

I. INTRODUCTION. PROGRESS OF COALFIELD REVISION, by JOHN S. FLETT, LL.D., D.Sc., F.R.S. 27

II. FIELD WORK 34

(A)—ENGLAND AND WALES :

1. London and South-Eastern District, by HENRY DEWEY 34
2. Midland District, by T. C. CANTRILL, B.Sc. .. 38
3. Yorkshire District, by C. N. BROMEHEAD, B.A. 46
4. Lancashire District, by W. B. WRIGHT, M.I.M.E. 59
5. Cumberland District, by BERNARD SMITH, M.A., Sc.D. 70
6. Northumberland and Durham District, by R. G. CARRUTHERS 81

(B)—SCOTLAND :

1. Ayrshire, by E. B. BAILEY, M.C., B.A. 89
2. Lanarkshire (chiefly) : Strathaven, Tinto and Douglas Districts, by M. MACGREGOR, M.A., B.Sc. 96
3. Fife and Kinross, by C. H. DINHAM, B.A. .. 108

III. PETROGRAPHICAL WORK, by HERBERT H. THOMAS, Sc.D. :

1. England and Wales 116
2. Scotland 116

IV. CHEMICAL WORK, by R. SUTCLIFFE, M.A. 117

V. PALÆONTOLOGICAL WORK, by F. L. KITCHIN, Sc.D., PH.D. :

1. England and Wales 120
2. Scotland 123

VI. MUSEUM OF PRACTICAL GEOLOGY, by W. F. P. MCLINTOCK, D.Sc. 125

APPENDIX I.—Some Recent Deep Borings in the London Basin, by HENRY DEWEY, J. PRINGLE and C. P. CHATWIN .. 127

„ II.—The Stratigraphical Relations between the Devon Red Sandstone (probable Barren Red Measures) and the Productive Coal Measures of Clackmannanshire, by D. HALDANE, B.Sc. 138

INDEX 144

(18418.) Wt. 2434—S. 108/142. 1250. 8/25. Wy. & S., Ltd. Gp. 50 (3).

593574

Digitized by Google

ILLUSTRATIONS

PAGE

FIG. 1.—Map of the Glacial phenomena west of Bradford .. 54

„ 2.—Vertical Sections showing correlation of principal coal seams and sandstones of lower part of Middle Coal Measures between Oldham and Ashton-under-Lyne .. 63

„ 3.—Section of Irwell Valley Fault at a point 275 yds. E.S.E. of All Saints' Church, Manchester 64

„ 4.—Generalised Sections in part of the Cumberland Coalfield 73

„ 5.—Comparative Vertical Sections of the Upper Limestone Group in Northumberland 85

„ 6.—Comparative Sections, South Ayrshire 92

„ 7.—Geological Map of the Tinto District, Lanarkshire .. 98

„ 8.—Section of Hosie Limestones on the shore opposite Seafield Tower, Kirkcaldy 110

„ 9.—Map showing outcrop and underground extent of the Lower Greensand 135

„ 10.—Geological Sketch Map of Inferred Unconformity between Devon Red Sandstone and Productive Coal Measures 139

„ 11.—Vertical Section at Devon Colliery.. 141

Digitized by Google

REPORT OF THE GEOLOGICAL SURVEY BOARD FOR 1924

TO THE LORDS OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

MAY IT PLEASE YOUR LORDSHIPS.—In accordance with our terms of reference, we, the Geological Survey Board, beg to submit our Fifth Annual Report on the work of the Survey and Museum.

1. We were in a position to report last year that the staff of the Geological Survey and Museum had been brought to the total authorised strength. The complete establishment has been maintained throughout the year, and it has therefore been possible to proceed with the full programme of work.

We wish to make reference to the retirement of Dr. Walcot Gibson shortly after the end of the year. Dr. Gibson entered the Survey as an Assistant Geologist in January, 1893, and has been Assistant to the Director, and in charge of the work in Scotland since October, 1920. Most of his 32 years' service has been devoted to coalfield survey, and he has been recognised in recent years as the most experienced of the official coalfield geologists. Two of the main areas of his work have been the North Staffordshire Coalfield, and the Concealed Coalfield of Yorkshire and Nottinghamshire, and his memoirs on these coalfields are models of their kind. In addition, he served as District Geologist in the Midland area. During the four years he spent in Scotland he contributed greatly to the efficiency of the Scottish staff by training young geologists in the most accurate and refined methods of coalfield investigation.

We feel that we must also refer to the death in July, 1924, of Sir Jethro Teall, who was Director of the Geological Survey and Museum from 1901 to 1914. He was thus Director at the time our predecessors, the Committee of Advice on the Geological Survey, were responsible for submitting reports to the Board of Education on the progress of the Survey, and for advising on the programme of work. When Dr. Teall took up duty as Director he was already of recognised eminence as a petrological worker—combining a mastery of physical and chemical methods, wide experience in dealing with petrological questions in the field, and the power of clear and succinct description and exposition. His Directorship was marked by great progress alike in the scientific and industrial branches of the work of the Geological Survey. He also effected an extensive reorganisation of the service, and the present programmes and methods of the Survey are to a large extent based on improvements he introduced.

Digitized by Google

2. The allocations of the Field Units engaged on surveys of the districts described by the programme for the year were as follows :—

(*a*) London and South Eastern District (primary six-inch survey).
(*b*) Midland District with North Wales (primary six-inch survey).
(*c*) Ayrshire Coalfield ... ... } (revision continued).
(*d*) Central Coalfield of Scotland ... }
(*e*) Northumberland and Durham District ... } (re-surveys
(*f*) Cumberland District ... ... } commenced
(*g*) Lancashire District ... ... } in 1921).
(*h*) Yorkshire Coalfield } (revision commenced in 1923).
(*i*) Fifeshire Coalfield }

The only change in arrangements made during the year was the preparation for the opening of a branch office at York for the Yorkshire unit. In all, there will now be four branch offices (Newcastle-on-Tyne, Whitehaven, Manchester and York) in addition to the Edinburgh and London Offices. We have no doubt that the creation of these branch offices serves to promote more economical working as well as the maintenance of contact between the Survey and other bodies and individuals interested in the areas in question.

Full particulars of the work carried out in each of the above areas in the course of the year are given in the Director's Report and in the Summary of Progress. Here we can only touch upon the general or novel aspects of the different activities.

3. The predominating features of the work of the Survey during the year were the prosecution of the primary six-inch survey of coalfields (with the areas into which their concealed parts may extend) and the revision of the coalfields originally surveyed on the six-inch scale, but not revised during the last thirty years. In particular, the survey of the Ayrshire Coalfield and the Central Coalfield of Scotland has been accelerated, with the approval of Your Lordships, by the temporary suspension of the primary six-inch survey of the Highlands ; and Your Lordships have approved our recommendation that this concentration on coalfield work should be maintained during 1925.

Outstanding progress has also been made in other directions, and attention must again be drawn to the noteworthy advances made in the publications of maps and memoirs. In the preparation of these memoirs the close co-operation between geologists in the field and members of the Petrographical, Palæontological and Chemical Departments calls for special comment. It may be mentioned in passing that consideration has been given to matters of typography, and that improvements have been effected in the covers of memoirs and in the general style of printing.

4. We mentioned last year that the Ordnance Survey had intimated that for those counties where the topography had recently

Digitized by Google

been revised the six-inch topographical maps would be issued in full sheets only, and we indicated the special arrangements that had been made to ensure that geological maps on the six-inch scale would continue to be issued in quarter sheets. We have now been informed that the Ordnance Survey have decided to revert to the practice of issuing the topographical six-inch maps in quarter sheets in view of the fact that the issue in this form is found to be more suited on the whole to the needs of the public.

5. We have at different times considered the various methods that have been suggested for the detection of underground deposits by acoustical, electrical, or gravitational means. Of the methods reviewed, the gravitational method seems the most promising. It would appear that the value of this method in the field of mineral and oil location is established for areas where significant differences of specific gravity occur, and where the presence of deposits has already been partially indicated in other ways. If the method were proved to be capable of yielding reliable information as to underground structure over a wide area where large differences of specific gravities might not exist, it would be of great utility in various parts of the Empire. We are therefore keeping a close watch on developments, but it may well be that the undertaking of a comprehensive test survey, such as would be necessary, would be a very costly proceeding, and might take some years to complete.

6. The importance of the information collected and published by the Geological Survey and Museum relating to mineral resources of Great Britain is now abundantly recognised. It is obviously necessary that the information should be as accurate and as up-to-date as possible. As an instance of the methods adopted to secure this, it may be mentioned that arrangements have been made for various members of the staff to visit working mines of lead, zinc, barytes, fluorspar, manganese, etc., in England and Scotland, and for contact to be maintained with new mining developments. Another volume of the series of Special Reports dealing with the mineral resources of Great Britain has been published during the year; three more are in the press.

7. We mentioned last year that owing to the high cost of printing the publication of the detailed reports prepared by Mr. Whitaker on the Water Supply of Wiltshire and Dorset had been deferred. It has now been decided to publish the volumes in a condensed form, and the necessary work of revision and editing is being undertaken. Many enquiries have been dealt with by the Survey during the course of the year on underground water supply, chiefly in relation to districts in the South-east of England.

8. The Survey continued to take advantage of the professional assistance of geologists outside the Survey who have special knowledge and experience of certain sections of the work. For example, Mr. Osborne White has been engaged in the preparation of memoirs on the geology of South-eastern counties, and is at present occupied in writing up the memoir on the Lewes Sheet as

Digitized by Google

a companion volume to his memoir on Brighton and Worthing, which has recently been published.

9. We had occasion last year to refer to the publication of four parts of Dr. Kidston's monograph on the fossil plants of the Carboniferous Rocks of Great Britain. Our hope that he would be able to complete the work has not been fulfilled, for he died suddenly in July, 1924, while engaged in South Wales on the collection of information for sections of the monograph. The publication was to include a summary of his conclusions accompanied by lists of fossils and horizons which would have been of priceless value to all workers in the field. Unfinished as it is, the monograph will establish Dr. Kidston's permanent claims to recognition as one of the greatest British systematic palæobotanists.

We record with high appreciation Dr. Kidston's bequest to the Geological Survey of his collection of fossil plants, with the cabinets containing them and the manuscripts relating to them.

10. Many schemes are now under way throughout the country for the construction of new roads. In the course of this work much information is obtainable that is of great value to the Geological Survey, particularly if the exposures of rocks and soils can be examined at an early stage of the operations. The Survey is being furnished by the Ministry of Transport with information regarding cuttings on the arterial roads of Greater London. As regards provincial schemes, where practically the whole of the work under the head of highways is in the hands of Local Authorities, arrangements have been made for these cuttings to be watched, as far as possible, by members of the Geological Survey staff stationed in the various districts. The Geological Society of London has also interested itself in this matter, and has circularised Local Authorities on the importance of affording opportunities to geologists for watching road sections. We welcome the co-operation of local geologists, to whose observations we attach much value, here as in other directions. We would earnestly request Local Authorities to keep the Geological Survey fully and promptly supplied with particulars of the location of new roads contemplated, and of the progress of those in course of construction.

11. Throughout the year the work of the Museum of Practical Geology has been overshadowed by the fact that the building was in a bad state of repair. The Museum has indeed been kept closed to the public since April, 1923. It was, however, found possible to provide access to the Survey Offices and Museum Library and Map room through the Piccadilly front of the building.

We had pleasure in announcing last year that the Government had decided to transfer the Geological Survey and Museum from Jermyn Street to a new building that is to be erected at South Kensington on the site recommended in 1912 by the Departmental Committee of the Science Museum and Geological Museum. The preliminary plans for this building are now under consideration.

Digitized by Google

It is contemplated that it will be possible to make provision for the much needed extended accommodation for the exhibition of specimens and for the development of the collections. The building will adjoin the Natural History Museum on the one hand and the Science Museum on the other. In this way it will be possible to give effect to the comprehensive scheme the Committee had in view for promoting the full co-ordination of the several national collections in London that are required to represent the whole field of geological science with its economic applications and its relations to other sciences.

12. The Geological Survey and Museum took part in the British Empire Exhibition, 1924. The exhibit was housed in the Government Pavilion and was designed to represent the different branches of Survey and Museum work. Among its features were :—a typical series of Survey maps selected from districts of economic and scientific importance in England, Scotland and Wales; specimens and diagrams illustrating the published Special Mineral Reports; special exhibits showing how rocks and fossils are used in such practical geological work as map-making, the search for coal in concealed coalfields, and the search for underground water; Geological Survey photographs showing examples of rock-formation, rock-disintegration, and the dependence of scenic features and physiography on geological structure.

13. The programme of field work for 1925 is :—

(*a*) London and Midland Districts : continuation of the primary six-inch survey, completion of the collection of new data for the Oxford memoir, minor revisions in the Lewes Sheet.

(*b*) Revision of the primary six-inch survey of Northumberland, Durham, Cumberland, Lancashire, Yorkshire, Ayrshire, Lanarkshire, Fifeshire (with Kinross).

(*c*) Continuation of investigation of underground water supplies and collection of records of borings with examination of specimens from them. Investigation of mineral resources.

F. G. OGILVIE,
Chairman.

24th June, 1925.

Digitized by Google

Digitized by Google

REPORT OF THE DIRECTOR OF THE GEOLOGICAL SURVEY AND MUSEUM FOR 1924

DURING the year 1924, no changes have taken place in the staff of the Geological Survey and Museum. The authorised establishment is complete, no vacancies have arisen, and no new appointments have been made. At the close of the year Dr. Walcot Gibson had only a few days longer to serve, having elected to retire on pension, and the question of his successor was under consideration. Early in January, 1925, Mr. Murray Macgregor, who had for four years supervised the work of the Survey in the Central Coalfield of Scotland and in the North-eastern Highlands, was appointed to succeed Dr. Walcot Gibson as Assistant Director in Scotland, and since then has taken on his duties.

It seems appropriate also to mention that two former Directors of the Geological Survey have died during the year. Sir Archibald Geikie was appointed temporary assistant geologist in 1855, geologist in 1861, Director for Scotland in 1867, and Director General in 1882. His work is too well known to need comment as he filled a large place in the scientific world outside of the Geological Survey. Among his official publications the following deserve special mention :— 'The Geology of Eastern Fife' (1902), 'The Geology of Central and Western Fife and Kinross' (1900) and 'The Geological Structure of the North West Highlands of Scotland' (1907) (of which he acted as Editor). He had been President of the Geological Society of London in 1890–92, and 1906–08, and of the Royal Society (1908–13), and had received the Order of Merit in addition to many scientific distinctions and honorary degrees.

Sir Jethro Justinian Harris Teall died at Dulwich on 2nd July, 1924. He was specially appointed to the Survey as Petrographer in 1888 and became Director in 1901 when Sir Archibald Geikie retired. He was responsible for a complete reorganisation of the Survey in all its departments in 1901 and the following years, and apart from his scientific work, which was of the highest merit, he has left a deep impression on Survey practice and organisation. Although no complete Survey memoir or map can be ascribed to him he contributed to many, and raised the standard of the Survey's petrographical work to a high level. He was President of the Geological Society in 1900–02, Vice-President of the Royal Society (1900–01) and was the recipient of many honours in Europe and America as a representative British scientific worker. Lady Teall has presented to the Survey a number of books from her husband's library and the very extensive series of pamphlets which he had

Digitized by Google

collected, principally petrographical. These are being catalogued and deposited in the library and will be of great value for reference.

Reference must also be made to the death of Dr. Robert Kidston, which happened in South Wales on 13th July, 1924. He was actively engaged on the preparation of his great monograph on 'The Fossil Plants of the Carboniferous Rocks of Great Britain,' of which four parts had been published and two were in the press or in manuscript. In connexion with this work he had visited South Wales to collect information and to examine specimens. His death, after a short illness, has removed the most experienced and learned systematic British Carboniferous palæobotanist and left a void that will be very difficult to fill. Dr. Kidston had served the Survey as a voluntary collaborator for many years. All the fossil plants of the Carboniferous rocks collected in the various areas under survey were referred to him for determination. He was surprisingly active and a rapid worker, and his services were of the greatest value to the field staff. His authority was unchallenged as his work was thoroughly critical and his knowledge was immense. The completion of his monograph will be a very heavy task, and it is hoped that special arrangements will be made to carry it out within a reasonable time. Fortunately Dr. Kidston has bequeathed to the Geological Survey his great collection of fossil plants, many of them types of new species and figured specimens described in his scientific papers and his monograph. With these he has given also the negatives of his published plates and many yet unpublished, which will be of great use should the monograph be ultimately completed. His manuscript notes, catalogues and bibliographical indexes have also been bequeathed to the Survey. In some respects this magnificent bequest is the greatest single acquisition which the Survey's collections have ever received and will make the Museum of Practical Geology one of the principal centres of systematic Carboniferous palæobotany in the world. In the present disorganised state of the Museum and Offices it is not possible to display this collection satisfactorily or even to render it accessible to scientific workers, but it is hoped that when the new Museum is built this magnificent donation will be suitably arranged and rendered available for study.

The publication of Mr. Whitaker's water supply memoirs had been temporarily suspended owing to the high cost of printing. Two manuscripts are in hand, on the counties of Wiltshire and Dorsetshire. After mature consideration it has been decided to reduce the size of these memoirs by condensing or omitting all the less important details. For this work Mr. F. H. Edmunds and Mr. Wilfrid Edwards have been detailed; they will visit the areas described, and as far as possible complete the information by collecting further data from local sources. This work will be commenced as soon as other engagements permit, and it is expected that these manuscripts will go to the printer during 1925.

The work of the Survey during 1924 was continued on normal lines. In addition to the offices in London and Edinburgh, branch

Digitized by Google

offices were maintained in Newcastle-on-Tyne, Whitehaven and Manchester. Towards the close of the year another branch office was being prepared for occupation at 14A, Parliament Street, York, where Mr. Bromehead and the Yorkshire unit would find local quarters. The selection of York was made on the grounds that it is equally accessible to all parts of the Yorkshire coalfield, and owing to the rapid and important developments in the Concealed Coalfield around Doncaster it is specially necessary to visit borings and shafts in that district at short notice.

In the South-eastern counties of England Mr. Dewey and his staff have begun the revision of the Aldershot Sheet (285), which is being mapped for the first time on the six-inch scale. The old map is fairly accurate, but a considerable amount of additional detail has been mapped and the sub-division of the drift deposits has been considerably elaborated. This district has special claims as a military and residential centre and is the source of many enquiries regarding sanitation and water supply. It is also of varied composition, especially suitable for the training of young geologists. Although only two field officers have been engaged on the work the revision of the Sheet is nearly half done. Mr. Dewey has been much engaged in preparing maps and memoirs for the press. The memoirs on Hertford (Sheet 239) and Dartford (Sheet 271), with the corresponding maps, were published during the year. The manuscripts of the North London memoir (Sheet 256) and the Romford memoir (Sheet 257) have been prepared by Mr. Bromehead, Mr. Dines and Mr. Edmunds, under the superintendence of Mr. Dewey, and the maps are being engraved and colour-printed. Mr. Dewey has also had in hand the preparation of a volume on the Copper Ores of the Midlands, Wales, the Lake District and the Isle of Man, for the series of Special Reports on British Mineral Resources. This was in the press at the end of the year. In the South-east of England the enquiries received about underground supplies of water are very numerous and important. Mr. Dewey devotes much time to such questions, and in connexion with them has visited several important deep bores and checked the records. Reports on some of these bores appear as an appendix to this 'Summary of Progress.' In this district also the new road cuttings have received much attention, and Mr. C. P. Chatwin has, with the help of the fossil collectors, obtained a considerable amount of palæontological material from these sources. Exposures of fossiliferous rocks in the neighbourhood of London are comparatively scarce; consequently these new road cuttings are of much interest. They often yield important evidence regarding the boundaries of the geological formations.

In the preparation of memoirs on the geology of the South-eastern counties the Survey continues to receive the assistance of Mr. Osborne White. During 1924 he has seen the memoir on Brighton and Worthing through the press, and the geological maps (Sheets 318 and 333) have also been published. In this district also Mr. John Rhodes has taken a set of useful photographs illus-

Digitized by Google

trating features of the local geology. The memoir on the geology of Marlborough (Sheet 266) by Mr. Osborne White has been passing through the press, and the geological map has been engraving. A small amount of revision was desirable, and has been carried out by Mr. Dewey's staff, assisted by Mr. Edwards. Mr. Osborne White was principally engaged in preparing the manuscript of a memoir on the Lewes Sheet (319), which will form a useful companion to his excellent memoir on Brighton.

A new edition of the Oxford memoir, which was written to describe the Special Oxford Map on the one-inch scale, is in preparation. The map is not at present to be revised, but Mr. John Pringle has spent about three months in the field collecting additional data regarding the fossiliferous horizons and the distribution of the palæontological zones of the Secondary rocks. He has also made use of lists of fossils in the Museum at Oxford, supplied by Mr. Bayzand with Professor Sollas's consent. Dr. Sandford, of Oxford University, has agreed to furnish a description of the gravels and alluvial deposits of this Sheet. More field work is required before this memoir can be completed, but the work is making satisfactory progress, and it is expected that the manuscript will be completed in 1925.

In the Midland district Mr. T. C. Cantrill has made considerable progress in overtaking the arrears of unpublished work in the North Wales coalfields. The Flint Sheet (108) has been published in Solid and Drift editions, along with the corresponding memoir. The Wrexham Sheet (121) and memoir are now in hand, and by the end of the year most of the six-inch coalfield maps were being engraved, the one-inch map was being dry-proofed, and the memoir compiled. Owing to the dispersal of the geologists who mapped this ground the task of completing and publishing the work presents considerable difficulties, but these are being gradually overcome. A revised Drift edition of Sheet 123 (Stoke-on-Trent) has been issued, and Dr. Gibson is preparing a new edition of the explanatory memoir. The earlier editions of both map and memoir had sold out. The Birmingham Sheet (168) has also issued from the press in Solid and Drift editions during the year, and the manuscript of this memoir is ready for the printer. This memoir has been by no means easy to complete, as so much valuable work has been done by local geologists in this area, and the literature has attained large dimensions and requires critical study. It has been decided to publish a separate economic memoir on the South Staffordshire Coalfield south of the Bentley Fault, as the boundary of the one-inch Ordnance sheets cuts this coalfield into sub-areas, which are difficult to describe individually and would involve much undesirable repetition if the coalfield details were included in the separate Sheet memoirs. All the six-inch maps of this coalfield are now published, and the memoir has been put in hand.

The memoir on the Wem Sheet (138), written principally by Mr. Pocock, was in the press at the end of the year. The corresponding

Digitized by Google

map has been published in Drift and Solid editions. The memoir is nearly ready for issue.

Field work in the Midland district has been carried on by Mr. Pocock, Mr. Whitehead and Mr. Robertson, principally in the Wolverhampton Sheet (153), which by the close of the year was practically completed, though there is a good deal of information regarding the old mining operations that has still to be collected.

Some work has also been done in the Shrewsbury (152) and Stafford (139) Sheets, in which the operations of this unit will be principally centred during the field season of 1925.

The Lancashire unit during the field season of 1924 completed mapping the Rochdale Sheet (76). It was found necessary to examine also a certain area outside this Sheet to the west to enable the boundaries and faults within Sheet 76 to be defined with greater precision. This work will be of use when Sheet 75 (Preston) comes to be revised. On the eastern side this unit has joined up with the Yorkshire unit, which is revising Sheet 77 (Huddersfield). The Manchester Sheet (85) has now been taken in hand and a start has been made in the district around Manchester. A great deal of mining information has to be collected and sifted as there are very extensive workings for coal in this area. The records of many bores for minerals and for water have been obtained and will prove of great value in interpreting the underground geology. As so much of the surface is built over or otherwise artificially altered, the records of building operations and the old geological maps must be relied on to furnish many data regarding outcrops of solid and superficial deposits.

Meanwhile the standards of the six-inch quarter-sheets which will be published, as containing workable coals and fireclays, have been prepared, and the dry proofs, or, in some cases, the engraved proofs, have been under consideration. About twenty quarter-sheets are passing through the press and most of them will be published during 1925. The dry proofs, Solid and Drift, of the one-inch Sheet (76) are being made, and notes for the memoir have been drawn up for the use of Mr. W. B. Wright, who will act as editor. The special feature of the revision of this area is the attempt to decipher the detailed succession of the Millstone Grit and Lower Coal Measures largely by means of the marine bands containing a goniatite fauna. In this Mr. Wright and his staff have constantly availed themselves of the advice and assistance of Mr. Bisat, who has specialised in the study of the goniatites of the Millstone Grit for many years, and has recently published a monograph on this subject.

In Yorkshire it was possible to establish a local office only towards the close of the year. Mr. Bromehead, who is in charge of this unit, has taken up his residence in York, and an office will soon be opened there. Field work was carried on by this unit in the Huddersfield Sheet (77) and good progress has been made. A large area of Millstone Grit has been revised and the Coal Measures have been examined in several districts. The old mapping proves fairly good, but many local details can be added as our knowledge of the sequence and

Digitized by Google

correlation of the beds is being considerably enlarged. The goniatite zones which are so important in this group of rocks in Lancashire are receiving attention, and it is believed will prove of much value in establishing correlations. A good deal of the ground revised in 1924 was not coal-bearing and the maps will not be engraved and published on the six-inch scale, but standards are being prepared for reference purposes in the office and library. As this one-inch Sheet will not be completed till 1925 publication will not begin for some months yet. Mr. Bromehead has also been engaged in writing the North London memoir (Sheet 256) which is now in the press and will be published early in 1925.

A great deal of work has been done during the year on the geology of the Concealed Coalfield of Yorkshire and Nottinghamshire. Dr. Gibson's memoir on this field was published in 1913 and is now sold out. Great advances have been made since that date, and before long this area will be the most important British coalfield from the point of view of coal production and reserves. As it is entirely buried under newer rocks such as the Permian and New Red Sandstone, no revision of the surface geology of this field proved necessary: the details investigated were wholly those of bores, shafts, sinkings and mines. By the kindness of the mining engineers and coal masters the information has been very freely placed at the disposal of Dr. Gibson and Mr. G. V. Wilson. They have examined many of the bores and shafts and visited the colliery offices in order to bring the information as thoroughly as possible up to date. Two sheets of vertical sections have been prepared illustrating the sequence in various parts of the field: they are being engraved and will be colour-printed. The second edition of the memoir has been in hand and the manuscript is nearly complete. When published the memoir will contain numerous bore and shaft records giving full details of the sequence at the more important mines.

In the Cumberland district Dr. Bernard Smith and his staff have been at work in two areas, both containing workable coals. One of these is the Whitehaven Sheet (28); the other is the Brampton Sheet (18). The revision of the Whitehaven Sheet is not yet complete though nearly so. This is a coalfield with extraordinarily complex structure. The sequence also varies greatly from place to place. The published maps have proved unsatisfactory and incomplete in many respects. By very careful and detailed study the Cumberland unit has been able to settle many of the obscure problems and to attain a reading of the geological structure which marks a great advance on our previous knowledge. The correlation of the coal seams is still uncertain in several respects, but as the work progresses many difficulties are being surmounted. Faulting is very common and some of the faults are of considerable magnitude; in the limestone areas the faults are often the seat of iron ore deposits and consequently all information that can be obtained regarding them may prove of importance in economic developments.

In the Brampton Sheet a considerable area, principally of

Digitized by Google

Carboniferous Limestone and New Red rocks, has been revised, but the maps are not yet ready for engraving. Coal has been worked in this area over a long series of years, and the study of the geology in greater detail than has hitherto been done will prove of interest as elucidating the problem of available reserves.

Dr. Smith has also corrected proofs of a second edition of his memoir on the Iron Ores of West Cumberland, Lancashire, etc. It is considerably enlarged and contains many details which have been obtained by frequent visits to the working mines. The Carlisle map (Sheet 17) with the small adjacent sheets, Silloth (16) and Longtown (11), are being dry-proofed and engraved, and the preparation of the corresponding memoir is well advanced. These will be published during 1925. Three six-inch quarter sheets of the Whitehaven coalfield are now published and several others are being dry-proofed or engraved.

In Northumberland and Durham field work has been carried on in the Ford, Alnwick and Rothbury Sheets (3, 6 and 9), and though a considerable amount of ground has been revised no Sheet has been brought to completion during the year. It is expected, however, that during 1925 the revision of the Alnwick Sheet will be finished. Some work has also been done in the Coal Measures around Newcastle and Gateshead in Sheets 14 (Morpeth) and 20 (Newcastle-on-Tyne). The publication of the six-inch maps is making rapid progress; twenty-four have been issued in 1923 and 1924 and twelve were engraving at the close of the year. Three one-inch Sheets are being dry-proofed or engraved: Norham (1), Berwick-on-Tweed (2), and Holy Island (4), and new editions of the respective memoirs are being prepared. Mr. Carruthers made an examination of many lead, zinc, and barytes mines in the North of England in order to acquaint himself with the most recent developments.

In Scotland the policy of discontinuing active field work in Highland Sheets and confining attention to the low grounds and coalfields was maintained for another year. This does not imply, however, that Highland geology was neglected, as six Highland memoirs were completed in manuscript or corrected for the press, and a very large amount of petrographical and palæontological work was done in the office in connexion with the memoirs. Of these the most important is the 'Tertiary and Post-Tertiary Geology of Mull, Loch Aline, and Oban', which was edited by Mr. E. B. Bailey; this volume contains the description of a varied and complex suite of rocks forming one of the most intricate regions the Geological Survey of Scotland has ever surveyed. A companion memoir on 'The Pre-Tertiary Geology of Mull, Loch Aline, and Oban' has been passing through the press. Portions of several one-inch Sheets are described in these two memoirs. Dr. Read's memoir on the geology of Banff, Huntly, and Turriff was also published; in it petrography bulks very largely, though the Glacial phenomena are also of great interest. A short account of the geology of Staffa, Iona and the adjacent parts of Mull has been compiled by Mr. Bailey

Digitized by Google

to serve as the Explanation of Sheet 43. Two sheets of the North-East Highlands have also been in the press, viz.: Golspie (Sheet 103) which includes the Jurassic rocks of the Brora Coast, and Strath Oykell (Sheet 102). The latter memoir contains some interesting petrography contributed by Dr. Read and Mr. Phemister. Both manuscripts are complete and ready for the printer. In this manner large areas of the Highlands that have been long in hand are now brought to an advanced state of publication; two Highland Sheets which have been surveyed but not yet published, viz.: 42 (Tiree) and 51 (Coll and Ardnamurchan), have still to be got ready for publication. When these are issued the state of Highland work will be much more satisfactory, and all publication arrears will have been overtaken before Highland field work is again started.

In the lowlands considerable progress has been made in the revision of the coalfields. Mr. Bailey and his staff in Ayrshire have completed the revision of the Kilmarnock Sheet (22) and have revised also a large area in the northern part of Sheet 14 (Ayr). Practically the whole of the Concealed Coalfield of Ayrshire, where the Coal Measures are overlain by New Red rocks and lavas, has been re-examined. Nearly all the six-inch quarter-sheets of North Ayrshire are now engraving or published, and a start has been made with the maps of South Ayrshire. Two short memoirs on the Economic Geology of North Ayrshire have been completed in manuscript and are in the press. The one-inch Sheet 22 (Kilmarnock) will next be taken in hand. Thirteen Ayrshire quarter-sheets were published during 1924 and seventeen were engraving. To illustrate the sequence in North Ayrshire a sheet of Comparative Vertical Sections has been drawn and will be published colour-printed.

In Lanarkshire attention has been directed principally to completing the revision of the older rocks which underlie the coal-bearing strata to the south of the Central Coalfield of Scotland. The coalfield itself has all been revised and mostly published, and during the year the one-inch Sheet 31, Falkirk, was issued in two colour-printed editions (Solid and Drift). This is the largest and most complex area of coalfield that has yet been represented on one of the new colour-printed maps. The small outlying coalfields of Muirkirk and Douglas are being revised but are not yet ready for publication. Another volume of the series of economic memoirs on the Central Coalfield has been edited by Mr. Macgregor and has made its appearance during the year, viz.: Area VI (Bathgate, Wilsontown and Shotts). The demand for these memoirs continues, and a new edition of Area V (Glasgow East, Chryston, Glenboig and Airdrie) has been edited by Mr. Macgregor and is now in the press. The Glasgow District memoir has also sold out, and Mr. Macgregor has edited a second edition, which also is printing.

In continuance of this useful series of short economic memoirs on Scottish coalfields Mr. Macgregor is writing an account of the Kilsyth and Kirkintilloch districts, while Mr. Dinham has a memoir in hand on the Clackmannan and North Stirlingshire Coalfield. The

Digitized by Google

revision of these areas is complete, but the geology is very complex and the mining information requires skilful interpretation. A beginning has been made with the publication of the six-inch maps of the Alloa coalfield, and the first revised quarter-sheet of Fifeshire has been sent to be engraved. Mr. Dinham's unit has been at work in West and Central Fife, principally around Saline, Dunfermline, Cowdenbeath and Kinghorn. While a fair area has been revised, it is too soon as yet to begin engraving the maps. The geology is often obscure and difficult, and many questions both of structure and correlation require to be considered. The colliery proprietors and mining engineers have been most helpful in affording access to the information in their possession.

The revised survey of the Silurian rocks of the South of Scotland by Dr. Peach and Dr. Horne, which has not hitherto been adequately published, has been advanced a further step by the issue during 1924 of a colour-printed one-inch map of the Moffat area (Sheet 16). At the same time the unpublished standard six-inch maps are being brought up to date under Dr. Peach and Dr. Horne's supervision. The new maps show the chert and black shale outcrops clearly by colour and have the drift deposits overprinted in stipple. Four of these one-inch sheets are now on sale and two others are engraving, and the work will be continued as rapidly as the more urgent demands of coalfield publication will permit.

One volume of the Special Reports on Mineral Resources of Great Britain has been published during the year, viz.: Analyses and Physical Tests of Refractory Materials; and three are in the press, two on Iron Ores and one on Copper Ores. This Copper Ores report is the thirtieth volume of the series, and several of them are now in a third edition. No new volumes of the Special Reports are being written at present, but a third edition of the Oil Shales of the Lothians has been called for and is in preparation. This memoir has long been recognised as a very complete and satisfactory account of an industry in which Scotland takes a unique place. During the year arrangements were made to visit most of the active mines of lead, zinc, barytes, fluorspar and manganese in Britain in order to collect notes of progress that will be useful when new editions of the Special Reports are prepared. This was done by various members of the staff both in England and in Scotland. The results are not at present to be published, but it is intended to keep in touch with the principal developments as occasion offers and to gather information that might be lost if any of the mines were closed or changed hands.

During the whole year the Museum of Practical Geology has been closed to the public, and H.M. Office of Works has been engaged in erecting timber supports to the roof. The exhibited collections have been covered with boards to protect the glass cases, and it has been impossible for the staff to work in the Museum or to examine the collections there. The stored specimens in the basement have also been to some extent unavailable for reference. A temporary entrance was provided on the Piccadilly front by convert-

Digitized by Google

ing one of the windows into a door-way, and by this means the public wishing to consult the scientific staff or to examine maps or books in the library could get admittance. The drawing office, chemical laboratory, petrographical department and geologists' rooms have been open to the staff only, as they are entered through the Museum. Further examination proved that the roof could not be repaired without great expenditure, and that owing to settlement of the foundations the walls were extensively cracked. It has now been decided by H.M. Office of Works that the present building must be condemned, and after serving for seventy-two years as a public museum it will not again be freely opened to the public. A new museum is to be erected on the site adjacent to the Science Museum and Natural History Museum, facing Exhibition Road, South Kensington, and the preliminary sketch plans are under consideration. At least two years must elapse before the new building is complete and the transfer can be effected. Meanwhile the present building will be rendered safe for temporary occupation, and the energies of the Museum staff will be directed to preparing the collections for removal and designing additional exhibits for the new museum. The library and map room will continue to be accessible to all enquirers, and when the temporary supports are erected it may be possible to admit students and scientific visitors to consult the material exhibited in the Museum galleries, though the building is not in a state that renders it suitable for ordinary Museum purposes.

In connexion with the enquiry into the question of the feasibility of the Severn Barrage scheme under the auspices of a Committee appointed by the Department of Scientific and Industrial Research, Mr. T. C. Cantrill and Mr. E. E. L. Dixon, in August, 1924, made a careful examination of all the exposures near the sites of the proposed dams and submitted a report with maps. Dr. Flett and Mr. Cantrill subsequently visited the district and prepared a brief summary of the evidence, with conclusions, for the information of the Committee.

I.—SURVEY WORK

(1)—ENGLAND AND WALES

Field-work

London and South-Eastern District.—Field-work was begun in Sheet 285 (Aldershot) by Mr. Dines and Mr. Edmunds under Mr. Dewey, District Geologist. A small amount of revision was undertaken in Sheet 266 (Marlborough) with the assistance of Mr. Edwards.

Midland District.—Field work was carried on by Mr. Pocock, Mr. Whitehead and Mr. Robertson in Sheets 153 (Wolverhampton), 152 (Shrewsbury), and 139 (Stafford) under the superintendence of Mr. Cantrill, District Geologist. Mr. Robertson also examined the rocks exposed in the new Colwall Tunnel and collected information on various mines.

Yorkshire District.—Work was continued in Sheet 77 (Huddersfield) by Mr. Wray, Mr. Stephens and Mr. Edwards, Mr. Bromehead acting as District

Digitized by Google

Geologist. Dr. Walcot Gibson and Mr. G. V. Wilson visited mines and borings in the Concealed Coalfield.

Lancashire District.—The revision of Sheet 76 (Rochdale) was completed; parts of Sheet 75 (Preston) were revised, and Sheet 85 (Manchester) was taken in hand by Dr. Sherlock, Mr. Lloyd, Mr. Tonks, Mr. Jones and Mr. W. B. Wright (District Geologist).

Cumberland District.—Work has been continued in Sheet 28 (Whitehaven), Sheet 22 (Maryport), and Sheet 18 (Brampton) by Mr. Dixon, Mr. Eastwood, Mr. Trotter and Mr. Hollingworth under the supervision of Dr. Bernard Smith, District Geologist.

Northumberland and Durham District.—Mr. R. G. Carruthers, District Geologist, and Mr. Burnett, Mr. Maden, Mr. Fowler and Mr. W. Anderson continued work in Sheets 3 (Ford), 6 (Alnwick), 9 (Rothbury), 14 (Morpeth), and 20 (Newcastle-on-Tyne).

Indoor Work

The manuscripts of the following memoirs were being written or edited for publication :—

Special Reports on the Mineral Resources of Great Britain :—
- Iron Ores: Haematites of West Cumberland, Lancashire, and the Lake District (Special Mineral Repts., Vol. VIII, *2nd Edition*).
- Refractory Materials: Fireclays. Analyses and Physical Tests (Special Mineral Repts., Vol. XXVIII).
- Iron Ores: Bedded Ores of England and Wales. Petrography and Chemistry (Special Mineral Repts., Vol. XXIX).
- Copper Ores of the Midlands, Wales, the Lake District and the Isle of Man (Special Mineral Repts., Vol. XXX).

Summary of Progress for 1923.

Water Supply of Wiltshire; of Dorsetshire; of Gloucestershire; of Derbyshire; and of Somersetshire.

Palæontology. Vol. II. Fossil Plants of the Carboniferous Rocks of Great Britain. Parts 5 and 6.

Explanations of Sheets 1 (Norham), 2 (Berwick-on-Tweed), 4 (Holy Island), 11 (Longtown), 16 (Silloth), 17 (Carlisle), 121 (Wrexham), 123 (Stoke-on-Trent) *3rd Edition*, 138 (Wem), 168 (Birmingham), 256 (North London), 257 (Romford), 266 (Marlborough), 319 (Lewes), and the special Oxford map. *2nd Edition*.

Concealed Coalfield of Yorkshire and Nottinghamshire (*2nd Edition*) and South Staffordshire Coalfield.

The following maps and memoirs were published or passing through the press in 1924 :—

I.—MAPS

Published.

½ inch to 1 mile :—
Sheet 20 with 24 (London, Dover and Brighton, revised solid edition).

1 inch to 1 mile :—
Sheet 108 (Flint, drift and solid editions), Sheet 123 (Stoke-upon-Trent, revised drift edition), Sheet 138 (Wem, drift and solid editions), Sheet 168 (Birmingham, drift and solid editions), Sheet 239 (Hertford, drift edition), Sheet 271 (Dartford, drift edition), Sheet 318 (Brighton, drift edition), Sheet 333 (Worthing, drift edition).

6 inches to 1 mile :—
Cumberland, 61 S.E.; 67 N.W. (New Ed.), S.W. (New Ed.).
Northumberland, 8 S.W.; 15 S.W., S.E.; 16 S.E.; 20 N.W., N.E., S.E.; 21 N.W., S.W., S.E.; 22 N.W., S.W.

Digitized by Google

Staffordshire, 62 S.E.; 67 N.E., S.E. (Worcs. 1 S.E.); 68 N.W., N.E., S.W.(Worcs. 2 S.W.), S.E. (Warw. 7 S.E.); 71 N.E. (Worcs. 4 N.E.), S.E. (Worcs. 4 S.E.); 72 N.W. (Worcs. 5 N.W.), S.W. (Warw. 13 S.W.; Worcs. 5 S.W.).
Worcestershire, 9 N.E.; 10 N.W., N.E., S.W.

In the press, engraving or colour-printing.

1 inch to 1 mile :—
Sheet 1 (Norham), Sheet 2 (Berwick-on-Tweed), Sheet 4 (Holy Island), Sheet 16 (Silloth), Sheet 17 (Carlisle), Sheet 256 (North London), Sheet 257 (Romford), Sheet 266 (Marlborough).

6 inches to 1 mile :—
Cumberland, 53 S.W.; 61 N.W., S.W.; 72 N.W.
Denbighshire, 28 N.W. (Flint 19 N.W.), N.E., S.W., S.E.; 29 S.W.; 35 N.W., N.E., S.W., S.E. (Flint 21 S.E.); 40 N.W., N.E. (Flint 24 N.E.), S.W., S.E.
Flintshire, 22 S.W. (Denbigh 36 S.W.).
Lancashire, 64 S.W., S.E.; 65 N.W., S.W.; 71 N.E.; 72 N.W., N.E., S.W., S.E.; 73 N.W., S.W., (S.E. and 81 N.E.); 79 N.E.; 80 N.W., N.E., S.W., S.E.; 81 N.W., S.W., S.E.
Northumberland, 6 N.E., S.E.; 7 S.W.; 16 N.W., N.E., S.W.; 17 (S.W. and S.E.); 21 N.E.; 22 N.E.; 27 S.W.; 32 N.W., N.E.

Vertical Sections :—
Sheet 91 (Sections of Borings and Shafts in the Northern Part of the Concealed Coalfield of Yorkshire and Nottinghamshire).
Sheet 92 (Sections of Borings and Shafts in the Concealed Coalfield of Nottinghamshire).

Copies of the following six-inch sheets, which are not to be published, were deposited in the Library for public reference :—
Anglesey, 8 N.W., S.W.; 9 (S.E. and 15 N.E.) (Carnarvon 3 N.E.); 15 N.W.
Cumberland (Drift editions), (9a S.W. and 15 N.W.), 9a S.E. (part); 10 N.W., N.E., S.W., S.E.; 15 N.E., S.W., S.E.; 16 N.W., N.E., S.W., S.E.; 22 N.W., N.E., S.W., S.E.; 23 N.W., N.E., S.W., S.E.; 29 N.W., N.E.; 30 N.W., N.E.
Shropshire, 6 S.W., S.E. (part); 7 S.W. (part), S.E. (part); 8 S.W. (part), S.E. (part); 9 S.W. (part); 13 N.W., N.E., S.W., S.E.; 14 N.W., N.E., S.W., S.E.; 15 N.W., N.E., S.W., S.E.; 16 N.W. (part), S.W.

II.—MEMOIRS

Published.

Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the Year 1923. 173 pp.; 14 text-figures. 1924. Price 4s. net.

Special Reports on the Mineral Resources of Great Britain :—
Vol. XXVIII.—Refractory Materials: Fireclays. Analyses and Physical Tests. By F. R. Ennos, B.A., B.Sc., A.I.C., and Alexander Scott, M.A., D.Sc. 84 pp.; 9 text-figures. 1924. Price 3s. net.

The Geology of the Country around Flint, Hawarden, and Caergwrle. (Explanation of one-inch Sheet 108.) By C. B. Wedd, B.A., and W. B. R. King, O.B.E., M.A., with contributions by G. W. Lamplugh, F.R.S., H. H. Thomas, M.A., Sc.D., W. C. Simmons, B.Sc., A.R.C.Sc., and T. C. Cantrill, B.Sc. 222 pp.; 6 plates; 9 text-figures. 1924. Price 6s. 6d. net.

The Geology of the Country around Hertford. (Explanation of one-inch Sheet 239.) By R. L. Sherlock, D.Sc., A.R.C.Sc., and R. W. Pocock,

Digitized by Google

B.Sc., with contributions by J. Pringle and C. P. Chatwin. 66 pp.; 2 text-figures. 1924. Price 1s. 6d. net.

The Geology of the Country around Dartford. (Explanation of one-inch Sheet 271.) By Henry Dewey, C. E. N. Bromehead, B.A., C. P. Chatwin and H. G. Dines, A.R.S.M. 136 pp.; 2 plates; 1 text-figure. 1924. Price 3s. net.

The Geology of the Country near Brighton and Worthing. (Explanation of one-inch Sheets 318 and 333.) By H. J. Osborne White, F.G.S. 114 pp.; 4 plates; 14 text-figures. 1924. Price 3s. 6d. net.

The Geology of the Thames Valley near Goring, as illustrated by the Model in the Museum of Practical Geology. By Sir Aubrey Strahan, K.B.E., Sc.D., F.R.S. 22 pp.; 2 plates. 1924. Price 6d. net.

In the press.

Special Reports on the Mineral Resources of Great Britain :—

Vol. VIII.—Iron Ores: Haematites of West Cumberland, Lancashire and the Lake District *2nd Edition.*

Vol. XXIX.—Iron Ores: Bedded Ores of England and Wales. Petrography and Chemistry.

Vol. XXX.—Copper Ores of the Midlands, Wales, the Lake District and the Isle of Man.

Monograph on the Fossil Plants of the Carboniferous Rocks of Great Britain. (Palæontology. Vol. II.), Part 5.

The Geology of the Country around Wem. (Explanation of one-inch Sheet 138.)

The Geology of North London. (Explanation of one-inch Sheet 256.)

The Geology of the Country around Marlborough. (Explanation of one-inch Sheet 266.)

(2)—SCOTLAND

Field-work

Ayrshire.—Field work has been continued in one-inch Sheet 14 (Ayr), and completed in Sheet 22 (Kilmarnock) by Messrs. Richey, Eyles, Simpson and A. G. MacGregor, under the supervision of Mr. E. B. Bailey, District Geologist.

Lanarkshire.—Under Mr. M. Macgregor as District Geologist the revision of one-inch Sheet 23 (Lanark) was continued by Messrs. Read, Ross and Phemister.

Fifeshire and Stirlingshire.—The revision of one-inch Sheet 40 (Dunfermline) has been continued by Messrs. Haldane, Allan and Knox under Mr. C. H. Dinham as District Geologist. Mr. Dinham has completed the re-survey of that part of the Stirlingshire coalfield which falls within Sheet 39 (Stirling).

Indoor Work

The manuscripts of the following memoirs are being written or prepared for publication :—

Completed.

The Geology of Strath Oykell and Lower Loch Shin (Explanation of one-inch Sheet 102.)

The Geology of the Glasgow District. *2nd Edition.*

Economic Geology of the Central Coalfield of Scotland :—

Area V.—(Glasgow East, Chryston, Glenboig and Airdrie). *2nd Edition.*

Economic Geology of the Ayrshire Coalfields :—

Area I.—(Kilbirnie, Dalry and Kilmaurs.)

Area II.—(Kilmarnock Basin, including Stevenston, Kilwinning and Irvine.)

The Geology of the Country around Golspie. (Explanation of one-inch Sheet 103.)

Digitized by Google

The Geology of Staffa, Iona, and Western Mull. (Explanation of one-inch Sheet 43.)

In preparation.

Economic Geology of the Clackmannan and North Stirlingshire Coalfield.
Economic Geology of the Central Coalfield of Scotland :—
Area I.—Kirkintilloch and Kilsyth.
The Geology of Ardnamurchan and Coll.
The Geology of Tiree.
The Oil Shales of the Lothians. *3rd Edition.*

The following maps, memoirs and sections were published or passing through the press in 1924 :—

I.—MAPS

Published.

1 inch to 1 mile :—
Sheet 31 (Falkirk, solid and drift editions), Sheet 16 (Moffat).
6 inches to 1 mile :—
Ayrshire, 7 N.E., S.E. ; 8 N.W., S.W. ; 17 N.W., N.E., S.E. ; 18 N.W., S.E. ; 22 N.W., N.E. ; 23 N.W., N.E. .. ..
Lanarkshire, 18 N.W. .. ..
Renfrewshire, 15 N.W. .. ..
Stirlingshire, 23 S.E. .. ..
Perthshire and Clackmannanshire, 140 N.W., S.W.
} Published 1924, but reported as published in Summary of Progress, 1923.

In the press, engraving or colour-printing.

1 inch to 1 mile :—
Sheet 103 (Golspie), Sheet 102 (Strath Oykell), Sheet 43 (Iona), Sheet 7 (Ballantrae), Sheet 4 (Wigtown).
6 inches to 1 mile :—
Ayrshire, 9 N.W. ; 12 N.E., S.E. ; 13 N.W., S.W., S.E. ; 18 N.E., S.W. ; 19 S.W. ; 21 S.E. and 22 S.W. ; 24 N.W. ; 27 N.W., N.E., S.W., S.E. ; 28 N.W. ; 33 N.W.
Lanarkshire, 19 N.E.
Renfrewshire, 11 S.W. ; 14 N.E.
Perthshire and Clackmannanshire, 133 S.W., S.E. ; 134 S.W. ; 139 N.E.
Fifeshire, 37 N.W.
Vertical Sections :—(Scale 1 inch=40 feet.)
Sheet 8. Ayrshire Coalfields (Areas I and II), Kilmarnock, Stevenston, and Kilbirnie Districts.

Copies of the following six-inch sheets, which are not to be published, were deposited in the Office for public reference :—

Dumfriesshire, 41.
Kirkcudbrightshire, 5 ; 7 S.W., S.E. ; 8 ; 12 N.E., S.E. ; 13 ; 14 ; 16 ; 20 N.E. ; 21 ; 22 ; 23 ; 24 ; 25 ; 26.
Lanarkshire, 39 N.W.
Sutherlandshire, 87 ; 88 ; 96 ; 104.

II.—MEMOIRS

Published.

Summary of Progress of the Geological Survey of Great Britain for 1924. *See* p. 18.
The Geology of the Country round Banff, Huntly and Turriff. (Explanation of one-inch Sheets 86 and 96.) By H. H. Read, M.Sc., A.R.C.Sc. 240 pp. ; 11 text-figures. 1923. Price 6s. 6d. net.

Digitized by Google

The Economic Geology of the Central Coalfield of Scotland :—
Area VI.—Bathgate, Wilsontown and Shotts. By M. Macgregor, M.A., B.Sc.; and E. M. Anderson, M.A., B.Sc.; with contributions by L. W. Hinxman, B.A., F.R.S.E.; and B. Lightfoot, M.C., B.A. 134 pp.; 5 plates; 5 text-figures. 1923. Price 5s. net.
Tertiary and Post-Tertiary Geology of Mull, Loch Aline, and Oban. (Explanation of parts of one-inch Sheets 43, 44, 51 and 52.) By E. B. Bailey, M.C., B.A.; C. T. Clough, LL.D., M.A.; W. B. Wright, B.A.; J. E. Richey, M.C., B.A.; and G. V. Wilson, B.Sc.; with contributions by E. M. Anderson, M.A., B.Sc.; H. B. Maufe, B.A.; G. W. Lee, D.Sc.; B. Lightfoot, M.C., B.A.; T. O. Bosworth, M.A., D.Sc.; and G. A. Burnett, B.Sc. Petrology by H. H. Thomas, M.A., Sc.D.; and E. B. Bailey, M.C., B.A.; with Chemical Analyses by E. G. Radley, F.C.S., and F. R. Ennos, B.A., B.Sc., A.I.C., and Palæobotany by A. C. Seward, M.A., Sc.D., F.R.S.; and R. E. Holttum, M.A. 445 pp.; 6 plates; 66 text-figures. 1924. Price 15s. net.

In the press.

The Economic Geology of the Central Coalfield of Scotland :—
Area V.—(Glasgow East, Chryston, Glenboig and Airdrie). *2nd Edition.*
The Geology of the Glasgow District. *2nd Edition.*
The Economic Geology of the Ayrshire Coalfields :—
Area I.—Kilbirnie, Dalry and Kilmaurs.
Area II.—Kilmarnock Basin, including Stevenston, Kilwinning and Irvine.
The Pre-Tertiary Geology of Mull, Loch Aline, and Oban.

II.—GENERAL WORK

A.—PETROGRAPHICAL DEPARTMENT

Work in the Petrographical Department has been carried out by the Petrographer mainly in connexion with the Tertiary Igneous Rocks of Ardnamurchan (Sheets 51 and 52 Scotland) in co-operation with Mr. Richey, and on the older rocks of the Ross of Mull and Iona (Sheet 43) in collaboration with Mr. Anderson. Dr. Thomas has completed some investigations for the Research Department of Woolwich Arsenal, and at the request of the Health Advisory Committee of the Mines Department has continued his investigations into the nature of dusts collected from colliery workings.

In Scotland Dr. Read and Mr. Phemister have prepared chapters on the plutonic and metamorphic rocks of the Strath Oykell (102) and Golspie (103) Sheets, which are now in the press. Mr. A. G. MacGregor has investigated the petrology of various districts in Ayrshire.

The number of rocks sliced, or in process of slicing, and registered in the collections to the end of the year are as follows :—

English	12,834
Scottish	23,831
Irish	445
Foreign	2,531
Total	39,641

This represents an increase of 1,329 in the registered rocks.

Of the corresponding sections 808 were made in the English Office, 342 in the Scottish Office, and 144 by private individuals.

Digitized by Google

Dr. C. A. Matley kindly presented a series of 35 rock-sections from the igneous rocks of Burntisland, Fifeshire, and these have been registered and added to the collections.

The collections have been freely referred to by officers of the Survey and others. In addition, 1,174 sections and 697 rocks have been dispatched on loan for study to Survey officers and 143 sections and 26 rock-specimens to private individuals.

B.—PALÆONTOLOGICAL DEPARTMENT

England and Wales.—The fossils added to the collections during the year numbered 12,950. These included 6,594 specimens of Carboniferous plants bequeathed to the Geological Survey by the late Dr. Robert Kidston. A valuable collection of about 3,000 photographic negatives of Carboniferous plants prepared by Dr. Kidston has also been received from the Trustees of his estate.

Fossil-collecting has been carried on chiefly in Lancashire, Cumberland, Yorkshire, Shropshire and Oxfordshire, in connexion with current Survey work. Progress has been made in the examination of the collections obtained.

Mr. Pringle visited deep borings in Buckinghamshire, Essex, Somerset, Warwickshire and Surrey. He also spent three months in Oxfordshire making field-observations necessary in the preparation of a new edition of the memoir on the special Oxford Sheet.

Dr. Kitchin has spent much time in editorial duties and in consultations for the purpose of defining the exact requirements of the Department, in regard both to Office and Museum accommodation, in the event of removal to new premises.

Mr. Chatwin and Mr. Pringle have paid visits to a deep boring at Virginia Water. Mr. Chatwin also examined sections in the Gault and Chalk at Burham, Kent. In addition to the study of Eocene and other specimens he has spent much time in editorial work, notably the preparation for the press of Parts 5 and 6 of the late Dr. Kidston's memoir on the Carboniferous plants. The palæontological exhibit shown at the British Empire Exhibition at Wembley, designed to illustrate the utilization of fossils in practical geology, was arranged and mounted in the cases by Mr. Chatwin and Mr. Hester.

In addition to their work in connexion with the current field-survey, the officers of the Department have dealt with many economic enquiries and have assisted advanced students and others engaged in research-work. Palæontological work has been rendered difficult, however, by the recent state of the Museum and the inaccessibility of the collections. These, for the most part, have not been available for the purposes of comparison or study. It has been necessary on some occasions to refuse help to applicants who desired to make reference to specimens in the Museum or to obtain the loan of fossils from the cases. Nevertheless, the number of specimens sent out of the Department on loan for the purpose of study was 3,758.

Scotland.—In Scotland Messrs. Tait, Manson and Strachan collected and registered 3,166 fossils, mostly Carboniferous, from natural exposures and borings.

Further progress was made toward the completion of the Survey exhibits of Scottish fossils in the Royal Scottish Museum, fossils belonging to the Kimmeridgian having now been incorporated.

C.—CHEMICAL DEPARTMENT

During the past year fifty-four quantitative rock analyses have been completed in the Survey Laboratory. Among these were sixteen assays for tin in samples from Lewis, and eleven analyses for Special Reports Vol. XXIX, Iron Ores.

Digitized by Google

Twenty-five qualitative examinations have also been made on materials sent in by officers of the Survey.

In connexion with the work for the Special Report on Iron Ores, an electrometric method for the determination of acid-soluble ferrous iron in alkaline solution was developed. An investigation into the method of estimating ferrous iron in silicate rocks showed a possibility of attaining distinctly more satisfactory results by the adoption of J. F. Pratt's method as modified by W. F. Hillebrand; and the unsatisfactory nature of the processes for the determination of the various forms of mineral sulphur compounds has prompted some further research.

D.—PHOTOGRAPHIC WORK

Mr. John Rhodes has taken 628 photographs during the year and has registered 151 left over from 1923. The number of registered negatives is now as follows:—

English Photographs..	2,942
Photomicrographs	1,604
Miscellaneous	1,222
Total	5,768

He has also made 1,675 prints, most of these being for the albums in London and Edinburgh or to serve as illustrations for Survey memoirs in the press. His work has also included the preparation of 76 lantern slides for demonstration purposes and of 26 enlargements.

III.—MUSEUM OF PRACTICAL GEOLOGY

The erection of a large wooden tower to support the southern section of the roof has added to the disorganisation of the collections, stored and exhibited, and has greatly hindered normal museum work. To provide public access to the library and map room it was found necessary to make an entrance door in the Piccadilly front and large numbers of readers and enquirers have availed themselves of the facilities thus provided.

The Museum staff prepared a comprehensive exhibit for H.M. Government Pavilion at the British Empire Exhibition; they also prepared loan exhibits for the Mining Association and the New Zealand Government. A considerable number of specimens were obtained from the colonial exhibits at the close of the Exhibition and have now been incorporated in the collections.

In the Mineral Department the investigation of the iron ores has been completed and a descriptive memoir is now in the press; 160 microsections have been prepared in the laboratory and have been transferred to the Survey collection. The card catalogue of the Inventory has been completed to date and 2,113 specimens in the Ludlam Collection have been labelled.

A manuscript catalogue of the specimens of borings has been completed and a card index is in course of preparation.

The additions to the Library during the year comprise 389 volumes of independent works, 2,567 volumes and parts of serials, 507 maps and 112 pamphlets in addition to the 'Teall' collection of pamphlets presented by Lady Teall. During the same period 294 volumes were bound and 524 maps mounted.

Digitized by Google

LIST OF DONATIONS DURING THE YEAR 1924

ACTON, T. A., ESQ., F.G.S.—A specimen of *Allorisma* cf. *variabilis* M'Coy from the lower part of the Millstone Grit, in the Waen Silica Mine, Gwerna-ffrwd, Mold, Denbighshire.

AGNEW, C. MORLAND, ESQ.—Ornamental vase in green porphyry.

ASHMORE, G. P., ESQ.—Specimens of (1) diamond, (2) concentrate from gravels, (3) native gold, from Akim, Gold Coast Colony.

BOSTON, THE RIGHT HON. LORD.—Specimen of 'cone-in-cone' structure in coal, from the Waencoed Colliery, Newport, Mon.

BROWN, G. F., ESQ.—Six specimens of *Plicatula barroisi* Peron, from the Cortestudinarium Zone of Wingfield Hill, near Coulsdon.

BWANA M'KUBWA COPPER MINING CO., LTD., THE.—Specimens of copper ore.

CUNNINGTON, LIEUT.-COLONEL R. H., R.E.—Two specimens of Echinoids, from the base of the Portland Stone series, Isle of Portland.

DAVIES, DR. A. M.—A specimen of *Hemiaster forbesi* J. W. Gregory, and a specimen of *Ophioglypha wetherelli* Forbes, from the basement-bed of the London Clay at Northwood, Middlesex.

FELDTMANN, W. R., ESQ., M.I.M.M.—A large specimen of graphite schist.

GAIKA GOLD MINING CO., LTD., THE.—Gold ore with visible gold, from the Gaika Mine, Southern Rhodesia.

GENN, F., ESQ.—A hollow flint containing white liquid.

GLOBE AND PHŒNIX GOLD MINING CO., LTD., THE.—Gold bearing reef, from the Globe and Phœnix Mine, Southern Rhodesia.

GOLDNEY, F. H., ESQ.—Three specimens of *Homomya*, and one specimen of *Pleuromya* from the Cornbrash, near Corsham, Wilts.

GOLIGHTLY, MRS., per C. E. N. BROMEHEAD, ESQ.—An Ammonite from the Great Oolite at Pinfarthings, near Minchinhampton.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, THE GOVERNING BODY OF, per DR. A. MORLEY DAVIES.—A specimen of *Enidothyris holcophora* S. S. Buckman, from the Aalenian (opaliniformis-scissum horizon) near Sherborne, Dorset; and a specimen of *Terataspis* (*Paralichas*) *kildarensis* Reed, from the Upper Ordovician of Ireland.

ISLIP IRON COMPANY, LTD., THE, per N. W. KIDNER, ESQ.—Three bones of *Steneosaurus sp.* (a marine crocodile) from the Great Oolite of Thrapston.

KIDSTON, the late Dr. R., F.R.S., Trustees of Estate of.—The collection of Carboniferous Plants formed by the late Dr. R. Kidston, comprising 6,594 specimens. Also about 3,000 photographic negatives of fossil plants, made by Dr. Kidston. Also a series of Coal specimens with Carboniferous fossils.

KING, W. W., ESQ.—Three specimens containing Gasteropods, from the Keele Beds at the Birmingham Waterworks tip, in Hagley Wood, near Stourbridge.

LACROIX, PROFESSOR A.—Nepheline syenite from Isle de Los; also specimens of beryl, pegmatite, etc.

LANE, G. W., ESQ.—A series of specimens from the Chalk at Burham, near Maidstone.

MALCOLM, G. W., ESQ.—Specimens of rock salt from 151 feet below surface, Heath Lane Shaft, Northwich, Cheshire.

MARSHALL, P., ESQ.—Suite of rocks from New Zealand.

MASCALL, G. S., ESQ.—Two specimens of enhydros.

Digitized by Google

MATLEY, DR. C. A., F.G.S.—A collection of Ordovician fossils from various localities in North Wales. Also 13 rock specimens and 35 sections from Burntisland, Fife.

M'TUGA MINE, THE PROPRIETORS OF THE.—Specimens of copper ore (chalcopyrite), from the M'Tuga Mine, Northern Rhodesia.

MURRAY, G. W., ESQ.—Emerald crystals from Wadi Nugrus, Egypt.

NEW AMIANTHUS MINES, THE PROPRIETORS OF THE.—Specimens of asbestos and crocidolite from Kaapschehoop, South Africa.

NIL-DESPERANDUM MINE, THE PROPRIETORS OF THE.—Chrysotile in veins from Southern Rhodesia.

PENROSE, J. D., ESQ. (on behalf of the Duke of Devonshire).—Samples of oil and bitumen from the Hardstoft No. 2 Well, Chesterfield, Derbyshire.

PIEDBOEUF, M. PAUL.—Four specimens of *Hostimella hostimensis* Potonié and Bernard, from the Middle Devonian of Germany.

POPHAM, J. L., ESQ.—Large specimen of malachite from the Bwana M'Kubwa Mine, North-Western Rhodesia.

PRINGLE, JOHN, ESQ., F.G.S.—A series of *Ephithyris bathonica* S. S. Buckman, showing variations, from the Great Oolite (Zone of *E. bathonica*) of Bunkers Hill Quarry, Enslow Bridge, Bletchington, Oxfordshire.

QUE QUE LIME WORKS, LTD., THE PROPRIETORS OF THE.—Samples of ironstone from Southern Rhodesia.

RHODESIAN CHROME MINES, LTD., THE PROPRIETORS OF THE.—Granular and massive chrome ore specimens from Selukwe, Southern Rhodesia.

RICHARDSON, L., ESQ., F.R.S.E.—A specimen of Ammonite and eight specimens of other Mollusca from the Inferior Oolite, ' Hard White ' or ' Pendle ' beds (scissum-Ancolioceras horizon), of New Duston, near Northampton.

RICHARDSON, W. A., ESQ., M.Sc., F.G.S.—Limonite ' box ' from the Northampton Sands.

RUTHERFURD, W. G., ESQ.—An inkwell cut in amethyst, from Auvergne, France.

SHAMVA MINES, LTD., THE PROPRIETORS OF THE.—Large specimen of gold-bearing reef, from Rhodesia.

SMITH, W. CAMPBELL, ESQ., M.A.—Anglesite with white fluor on galena from Leadhills, Lanarkshire.

SPENCE, PETER, AND SONS, LTD., MESSRS.—Octahedral crystals of alum.

STAVELEY COAL AND IRON COMPANY, LTD., THE.—A large block of coal, from No. 1 Colliery, Markham, Derbyshire.

TRANSVAAL PLATINUM MINES, THE PROPRIETORS OF THE.—Platinum ore specimens from the Transvaal Platinum Mines, Naaboom Spruit, Transvaal.

WANKIE COLLIERY COMPANY, LTD., THE.—Coal specimens from Wankie, Southern Rhodesia.

WOLLASTON, T. C., ESQ.—Opal from Tintin Bar, Australia.

JOHN S. FLETT,
Director.

Digitized by Google

Digitized by Google

SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY AND MUSEUM FOR 1924

I.—INTRODUCTION

Progress of Coalfield Revision

THE demand for accurate revision of the British coalfields continues to be insistent, and this work is being carried on actively in the majority of the districts to which Survey geologists are assigned. The work is necessarily slow because the available information is often very large and must be very carefully sifted before final conclusions are reached. For the utilization of our national resources of minerals (including fuels, ores, building stones and underground water supply) no greater service could be performed than the provision of an accurate series of maps on as large a scale as possible, showing the structure and geological composition of the country so far as they can be ascertained with the data available at the time of publication. Such maps provide an indispensable basis of work for the civil engineer and the mining engineer, but to serve their purpose adequately they must be both accurate and up to date. New information constantly accumulates, especially where mining operations are in progress; this often clears up difficulties or reveals inaccuracies in the previous interpretation of the geological structure and not seldom proves that what was considered to be simple is in reality very complex. The frequency with which revision of the maps should be undertaken depends partly on the rate of progress in our knowledge and partly on the relative importance of the district as an economic field. Some of our coalfields—such as South Staffordshire, for example—have been worked for many years and have long passed their maximum output. Others are in course of development and are destined to attain great importance in the future. An example of the second class is the Concealed Coalfield of Yorkshire and Nottinghamshire. The problems which meet the field geologist are essentially different in these two cases. In an old coalfield there is abundance of mining information, though much of it may be unsatisfactory owing to the unreliable nature of the records, which often can no longer be checked. In the new coalfields where much of the ground is yet unproved, the information may be remarkably scanty, but it is mostly recent and reliable and the fullest possible use must be made of it owing to the economic developments which are contemplated.

The primary basis of the Geological Survey's mapping is the Ordnance Survey map on the scale of six inches to one mile or 1 in

Digitized by Google

10,560. No better map could be desired for general purposes, the only possible objection to it being that in districts which are densely populated the topographical details of roads, streets and buildings are so dense as almost to prohibit the insertion of geological information. Many Surveys use a field map on a scale about half as large (1 in 25,000) but in coalfields particularly six inches to one mile is the generally adopted scale and in oilfield surveys often eight inches to one mile. In Britain the sheets of the map on the scale of 25 inches to one mile are occasionally used in districts of very great complexity, but only for the insertion of field notes or for reproduction in plans of small and very important areas.

When the Geological Survey was instituted in 1832 and for many years subsequently six-inch maps were not available for many parts of Britain, and the first survey of Cornwall, Devon, South Wales and most of the South and East of England was executed on the one-inch maps. This of course was barely sufficient to represent the geology even of districts containing no important minerals and of comparatively simple structure such as the Chalk and Tertiary areas of many Eastern counties. When survey work was extended to the North of England and to Scotland the six-inch topographical maps had been published and were used by surveyors in the field. In course of time it became imperative to resurvey the coalfields and mineral districts originally done on the one-inch maps, and this work is still in progress and will ultimately be completed. This six-inch revision has been executed for the South Wales coalfield and for a large part of Cornwall and South Devon. In the London district and many parts of the South-east of England extensive areas have been resurveyed on the six-inch scale for the purpose of inserting the drift deposits which had been omitted in the early survey based on the one-inch maps. Similarly the coalfields of the Midlands have either been revised or are at present in course of revision. Only those maps which refer to mining districts and mineral areas are engraved and published on the six-inch scale, but coloured copies of most of the six-inch sheets which have been geologically surveyed are accessible to the public for reference in the libraries of the Survey in their London and Edinburgh offices. For those who wish to ascertain the possibilities of water supply, the nature of building sites, and the geological conditions affecting agriculture, horticulture and public health, these unpublished six-inch maps contain valuable information.

The coalfields of Lancashire, Yorkshire, Northumberland, Durham, Cumberland and Scotland were all surveyed originally on the six-inch scale, and most of the sheets were engraved and published (hand-coloured) before the year 1880, when six-inch publication was temporarily suspended.

In 1892 it was decided to begin a revision of the most important districts where there was an active mining industry and the original geological maps were no longer satisfactory. Sir Archibald Geikie sent Sir Aubrey Strahan to South Wales to prepare a new series of

Digitized by Google

six-inch maps of that coalfield and subsequently concentrated a group of geologists or geological unit in that field. The revision of the North Staffordshire coalfield was begun in 1894 and about the same time some revision was done in the Whitehaven coalfield. In 1894 also the Fifeshire coalfield was partly re-examined and though no new six-inch maps were issued the results were published on a second edition of the one-inch map, Sheet 40. Since these dates in nearly all the coalfields of Great Britain the six-inch maps have been revised or are undergoing revision. The resurvey of South Wales was completed in 1914 and publication of the revised sheets was then far advanced and is now completed. North and South Staffs, Nottingham, Leicestershire, Derbyshire, Flintshire, Cheshire and Warwickshire have now the revised six-inch survey published. In Scotland the East Lothian and Midlothian coal and oil-shale fields were first revised and are now published in new editions. The Central Coalfield of Scotland (Lanark, Stirling and Dumbarton) is also completely revised. North Ayrshire is now published in revised six-inch quarter-sheets and the revised one-inch map is being drawn for the engravers. The Alloa or Clackmannan coalfield is now also revised and publication has begun.

The coalfields which at this date are in course of revision and of which the new maps have not yet appeared are as follows: Coalbrookdale, Wrexham (Denbighshire), Lancashire, Yorkshire, Northumberland and Durham, Cumberland. In Scotland revision work is in progress in South Ayrshire, South Lanarkshire and Fife. In the oil-shale fields of the Lothians some sheets have been revised a second time.

Of the areas above mentioned Denbighshire, South Staffordshire and Clackmannan are completed and are awaiting final publication. The other areas were only begun in 1921 and will not be published completely for a considerable number of years. In these, however, the original survey was on the six-inch scale, was more recent and more thorough than in the southern coalfields. Consequently the need for revision was less urgent. All the more important coalfields that have not been revised are receiving attention, but certain small coalfields have not yet been taken in hand. These include Bristol, Forest of Dean, Forest of Wyre, Shrewsbury, Lebotwood, Clee Hill, and (in Scotland) Sanquhar and Campbeltown. The Canonbie coalfield on the border between England and Scotland was the subject of an important report by Dr. Peach and Dr. Horne in 1903.

The following list shows the state of publication of the revised six-inch coalfield maps at this date:—

England and Wales

Revised series published complete:—

Brecknock 1905–1908, Carmarthen 1908–1909, Cheshire 1923, Derbyshire 1903–1921, Flintshire 1923, Glamorganshire 1905–1908, Leicestershire 1905, Monmouthshire 1908, Nottinghamshire 1910–

Digitized by Google

1921, Pembrokeshire 1921, Staffordshire 1903–1924, Warwickshire 1922–1923.

Revision in hand. Publication begun :—

Cumberland, Denbighshire, Durham, Lancashire, Northumberland, Westmorland, Yorkshire.

Revision not yet begun :—

Bristol, Forest of Dean, Forest of Wyre, Lebotwood and Shrewsbury, Clee Hill.

Scotland

Revised maps published :—

Edinburgh 1906–1921, Haddington 1907–1908, Linlithgow 1908–1921, Renfrewshire 1921–1924, Dumbarton 1912–1923, Lanarkshire 1909–1924.

Revision in hand : some revised maps published :—

Ayrshire, Fifeshire, Clackmannan, Stirling.

Revision not yet begun :—

Dumfriesshire (Sanquhar and Canonbie), Argyllshire (Campbeltown).

Although the revised six-inch maps are on the same scale as the original six-inch maps there are many points of difference between them. Much additional information has been collected and inserted on the maps. There are, of course, individual peculiarities : some geologists produce a map which is loaded, and perhaps sometimes overloaded, with detail ; others prefer to make the map less elaborate and to reserve much of the information for publication in the corresponding memoir. But as a whole the new maps show much more detail than the old ones. The standard of size has also been altered, for the new maps are published in quarter-sheets representing six square miles, while the old maps were whole sheets of twenty-four square miles. Many of the new maps also contain a generalized vertical section showing the sequence and average thickness of the strata that outcrop in the area delineated. The old Sheets, however, were mostly engraved on copper and were beautiful examples of cartography ; the new quarter-sheets are produced by the much more rapid and much cheaper process of helio-zincography, but they serve their purpose equally well and save much time in preparation. In the old maps certain kinds of ' drift ' like boulder clay, sand and gravel were often represented by an engraved stipple ; the new quarter-sheets show only boundaries of both solid and drift, but may be obtained hand coloured as ' drift ' or ' solid ' editions. There are many other minor respects in which the two series differ, but these may be summed up by saying that in the new maps various devices have been adopted to increase the amount of information conveyed by the map without at the same time rendering it difficult to understand.

Digitized by Google

At the present time, as will be seen from the district reports in this Summary of Progress, revision work is being actively carried on in all the principal coal-bearing areas of Britain. In Scotland the revision is in an advanced state, for the only important field that has not been completed or nearly completed is Fifeshire. In that area a unit has been at work for two field seasons; and the new maps of the Dunfermline and Lochgelly coalfields are nearly ready to be engraved, but a large part of Central and Eastern Fife has yet to be revised. The Central or ' Lanarkshire ' coalfield is revised, together with its outlying areas in Stirling and Clackmannan. The small but important fields of Muirkirk and Douglas are in course of revision. About two-thirds of the Ayrshire coalfield has now been revised, and many of the six-inch maps are published or in the press. By the end of the present field season Muirkirk, Douglas and Ayrshire should be nearly completely revised. When this is done there will remain only Sanquhar, Campbeltown, Canonbie and Eastern Fife, but the revised maps of the Midlothian field were issued about twenty years ago and a re-examination of this ground should soon be undertaken. The Brora coalfield (of Jurassic age) has recently been revised by Dr. G. W. Lee, and a new one-inch map and memoir are in the press.

In Northumberland Mr. Carruthers and his staff began revision in 1921, working from the Newcastle Office. A start was made in the extreme north of the county, at Berwick-on-Tweed, and the Scremerston coalfield, which also contains some oil-shales, has been resurveyed. This unit has now reached Alnwick and Morpeth, and the revision of the Carboniferous Limestone fields on the east coast is fairly complete. Work has been done also in the Coal Measures near Newcastle. The new six-inch maps are passing through the press, and some of the new one-inch maps and memoirs will shortly be issued.

The staff working in Cumberland under Dr. Bernard Smith has met with many difficulties in the Whitehaven coalfield, where the sequence and structure were not previously well understood, and have proved to be exceptional in many respects and very variable. About half of this coalfield is now revised, and the limestone areas around Brampton, which contain workable coals, are also being resurveyed. Meanwhile they have completed the Carlisle one-inch sheets, which are now being engraved and colour-printed.

The revision of the Lancashire coalfield was begun in 1921 by Mr. Wright and his staff. They have completed the resurvey of the Rochdale Sheet and are now engaged in the Manchester Sheet. Many six-inch maps of North Lancashire are now engraving, and the one-inch Sheet 76 is being drawn for engraving, and the descriptive memoir is being prepared.

The large and important Yorkshire coalfield which extends into Notts and Derby has been revised in the district south of Retford and Sheffield, and the new maps are published with memoirs. A memoir was also published in 1913 on the structure of the Concealed

Digitized by Google

Coalfield which lies under the Permian and Trias; during the past year a much enlarged second edition of this important memoir has been prepared by Dr. Walcot Gibson and Mr. G. V. Wilson, and will soon go to press. The northern and western part of the Yorkshire coalfield around Leeds, Huddersfield and Barnsley has not yet been revised, but Mr. Bromehead and his staff began this work last year in the Huddersfield Sheet, and some of the new six-inch maps will soon be in the engravers' hands. An office has been opened in York as a local centre from which it will be easy for the District Geologist to collect new information and keep in touch with local developments and enquiries.

Revision work in the Midland coalfields has been in progress for over twenty years, and many new maps have been issued. The completed coalfields are Warwickshire, Cheadle, Derbyshire, North Staffordshire. During the past year South Staffordshire has been completed, and the six-inch maps are published. The one-inch map and the memoir on the south half of this coalfield are now in hand. Before the one-inch maps of the centre of England can be published it is necessary to revise considerable areas outside the coalfields, some of which may ultimately prove to contain workable coals. At present the survey is being carried on in the Stafford, Wolverhampton and Shrewsbury Sheets, principally on Triassic rocks but also on some Carboniferous and pre-Carboniferous areas. There remain to be undertaken the Shrewsbury and Lebotwood coalfields, the Forest of Wyre and Clee Hill, but these are all comparatively small and not of the first importance. The Lichfield, Coventry and Birmingham maps have been issued of recent years with corresponding memoirs (except Birmingham, which is in the press). A new edition of the North Staffordshire Sheet has been printed, and a third edition of the Stoke-on-Trent memoir will soon be ready.

At the outbreak of war in 1914 the field work of the revision of the North Wales coalfields had been completed, but publication had hardly begun. Since 1920 the Liverpool and Flint Sheets have been issued with their memoirs; the Wrexham Sheet is now in hand and the Oswestry Sheet will then be prepared for publication. This will complete the revision of the North Wales coalfields, but publication has been delayed not only by the intricacy of the geology, but also by the necessity of finishing other tasks which appeared to be more urgent, such as the Special Reports on the Mineral Resources of Great Britain, and by the scattering of the members of this unit consequent on the reorganisation of districts.

The revision of the British coalfields on the six-inch scale, which is at present the principal work of the Geological Survey, involves also the preparation of new descriptive memoirs explanatory of the maps. These memoirs contain many particulars which it is impossible to insert on the six-inch quarter-sheets, with records of variation, thicknesses and other characters both of the coal seams and of the strata associated with them. In many cases it is advisable to publish

Digitized by Google

the more important bore-records and shaft sections in considerable detail. Formerly special sheets of vertical sections were published, giving selected illustrations of the sequence in the different coalfields; the preparation of such vertical sections is now being resumed and three new colour-printed sheets are in the press—two for the Concealed Coalfield of Yorkshire and Nottinghamshire, and one for North Ayrshire. In Scotland it has been the practice for several years to issue memoirs on the Economic Geology of certain coalfields which contain as full an account as seems necessary of the special information required by mining engineers, as apart from the general regional geology of the district. These memoirs have been well received, and several additions to the series are in the press. An economic memoir on the South Staffordshire coalfield south of the Bentley fault is also in preparation and will be the first special economic memoir on one of the English coalfields.

As survey work in the Scottish Highlands is temporarily held up to allow the maps of important Scottish coalfields to be more rapidly issued, the only field-work that is being undertaken in Britain in addition to coalfield revision is the resurvey of the south-east of England, including the London district. In this area four one-inch maps were in the press and two were undergoing revision during 1924. The importance of geological information in its bearing on questions of water supply in this region makes it necessary to collect all the available information and place it on record. The search for underground water supplies becomes more intensive every year owing to the demands of public health and the establishment of new centres of population, and special memoirs on this subject have been prepared for most of the counties of the south-east of England.

JOHN S. FLETT.

Digitized by Google

II.—FIELD WORK

(A)—ENGLAND AND WALES

1. LONDON AND SOUTH-EASTERN DISTRICT

HENRY DEWEY, District Geologist.
H. G. DINES, A.R.S.M., A.M.Inst.C.E.
F. H. EDMUNDS, B.A.
WILFRID EDWARDS, B.A. } Geologists.

Work in the London and South-Eastern District was continued in the Marlborough and commenced in the Aldershot areas. The primary six-inch survey of the Jurassic rocks of the Marlborough map (Sheet 266) was completed and fresh ground was broken in the Aldershot map (Sheet 285). The Marlborough map is being engraved and the memoir by Mr. H. J. Osborne White is at the printers.

The maps and memoirs of the Dartford (271) and the Hertford (239) areas were published during the autumn: the North London map (256) is colour-printed and the memoir will shortly be published. The Romford map (257) has been engraved and the manuscript of the memoir is complete.

During the spring Mr. Dines visited the mines raising galena, barytes and calcite in North Wales and the Shropshire borders, and in July Mr. Dewey visited the Cornish tin and wolfram mines. Mr. Dewey completed the manuscript of the Special Report upon Mineral Resources, Vol. XXX. 'The Copper Ores of the Midlands, Wales, the Lake District, and the Isle of Man,' and the memoir is now at the printers.

Sections exposed in the road-widening schemes have been examined and photographed. The Dorking-Redhill road shows sections in the Gault and Lower Greensand: fossils were collected and are being determined by Dr. Spath.

ALDERSHOT SHEET

In the London District work was commenced in the Aldershot area (Sheet 285) by Messrs. Dines and Edmunds.

Mr. Edmunds has mapped the Gault from north of Compton to Tyting Farm near St. Martha's Church, and finds that the outcrop is everywhere narrow and locally completely faulted out. A fault trending eastwards from Artington to Warren Farm has thrown down the beds northwards; south of Pewley Hill it appears to have cut out the Gault, as the Folkestone Sands rest against the Chalk. In a field ¼ mile west of Braboeuf Farm shallow borings showed a fault-breccia composed of about equal proportions of Gault and

Digitized by Google

Chalk fragments. This fault appears to terminate against the N.W.—S.E. fault shown near Warren Farm on the Old Series map (Sheet 8), but westwards its termination has not yet been traced.

The Lower Tertiary beds have been mapped from near Down Place eastwards to Merrow and everywhere are of the Reading type: no Thanet Sands have been seen.

The London Clay presents its normal characteristics. Loamy beds have, however, been noticed by Mr. Dines near Russellplace Farm, but absence of sections does not permit their comparison with the Claygate Beds. Mr. Edmunds observed some lilac clays of the Claygate Beds in the steep bank immediately southwards of Pyrford Church, while at Messrs. Keen's Brickworks, Pitch Place, an 8-ft. face of buff loam rests on a heavy burly clay, the junction being marked by a band of iron-pan nodules, of which each nodule measures about 2 in. thick by 1 to 1½ ft. in diameter. The outcrop of the Claygate Beds is, however, not continuous, the exposures consisting of outliers.

Mr. Dines has mapped the Bagshot Sand between Aldershot and Woodstreet. At Ash, on the west, and east of Willey Green, the beds form a marked feature, but near Wyke between these localities a water-logged flat occurs. Mr. Edmunds has found that near Sutton Place a much smaller area than that shown on the old map is occupied by these sands.

A wide area of the Bracklesham Beds has been surveyed: it consists of flat country, covered with peat or loamy sand, and is often waterlogged. Mr. Dines has observed a small scarp near Ash and at Normandy Common formed by the upturned edges of these beds. Mr. Edmunds's mapping shows that the beds near Worplesdon are gently flexured, the folds trending north-east and south-west. West of Hook a N.N.W.–S.S.E. fault downthrows the beds to the west.

The Barton Sand composes most of the Chobham Ridges and the Fox Hills which extend southwards from Camberley to Ash Vale. Long spurs project eastwards from this mass at Bisley Camp and at Sheets Heath, and outliers occur east of Staffordlake, at Standing Hill, and at Cobbett Hill and Henley Park. The area mapped as Barton Sand is considerably larger than that formerly shown. Slight flexuring of the beds occurs, but the general dip is southerly as far as Crown Prince Wood and northerly, south of that wood. The northerly dip increases to about 10° at Surprise Hill. Mapping has brought out the anticlinal structure of the valley of the Blackwater between Ash Vale and Frimley. Mr. Edmunds has mapped some small outliers near Worplesdon.

The Chobham Ridges have been protected from erosion by a tract of Plateau Gravel which maintains a nearly uniform level of 400 ft. for many miles, but falls gradually to the height of 380 ft. at Surprise Hill near Ash Vale.

Mr. Dines has noted that eastwards this mass ends abruptly at the edge of the plateau in a line, which, though indented, is not so

Digitized by Google

deeply notched as is the western margin. Long flat-topped spurs of gravel project westwards ; they lie about 10 to 15 ft. lower than the surface of the main plateau, from which they are separated by a terrace feature. This upland terrace trends nearly parallel with the Blackwater and may mark a former course of that river.

Two tracts of gravel, at Farnborough Hill and at the Priory, ¼ mile east of Farnborough Station (South-Western Railway), respectively, are about 300 ft. above O.D. and may be remnants of a plateau. Two other tracts occur east of Willey Green, at a height of 200 ft., which have been classed as Plateau Gravel. In the area mapped by Mr. Edmunds small spreads of Plateau Gravel occur at 190 ft. above O.D. at Ockham Common, and around Blackmore Heath, Ockham, and a smaller tract near the inn at Broad Street, 2 miles north-west of Guildford.

The terraces of the Wey have been separately mapped and the terms used for those of the Thames, i.e., the Boyn Hill, the Taplow and the Flood Plain, applied to them.

Spreads of gravel, correlated with the Boyn Hill terrace, form remnants of a terrace of the River Wey between Guildford and Ockham, and Wisley. This terrace lies almost wholly to the south of the river, and is well preserved south of the line Send Heath-Ripley-Ockham Common. The gravel deposits are in some places 10 ft. thick. Similar spreads are found north of the river around Sutton Place. The height above present stream-level is about 40 ft. at the lowest parts of the terrace but rises to 90 ft. locally. The Wey at the Boyn Hill stage almost invaded the valley of the Mole, but was deflected northwards by the ridge of Bagshot Sand capped with Plateau Gravel, at Ockham Common.

Large tracts of gravel on both banks of the Wey have been classed as the Taplow and the Flood Plain terraces respectively, but most of them as the Taplow terrace. All three terraces are well seen at the new part of the Royal Horticultural Society's Gardens at Wisley.

Mr. Dines has shown that at least two terraces are preserved in the valley of the Blackwater. East of the river an unbroken tract of gravel extends from the northern margin of the map southwards to Ash. It lies at the same level as the alluvium near the river but rises to about 10 ft. above that level on its outer margin ; its boundary, however, is obscured by deltas of gravel washed down from the high ground of the Chobham Ridges and the Fox Hills. The lower tracts are water-logged and so rendered difficult to work for gravel.

On the western side of the valley the lower terrace is represented near Hawley only, but there is a marked terrace 20 ft. to 40 ft. above the river level at Farnborough and to the south-west of Frimley.

Marlborough Sheet

During the early winter of 1923 the revision of the Marlborough area (Sheet 266) had to be deferred, but in the spring of 1924 Mr. Edwards revised the mapping of the Lower Greensand, Gault,

Digitized by Google

Upper Greensand and base of the Chalk, along the outcrops from Highway to Burderop Wood, south of Swindon. Corrections were also made to the Middle and the Upper Chalk boundaries in other parts of the Sheet. A new edition of that map is now being engraved.

The Lower Greensand rests unconformably on the Kimmeridge Clay and is overlapped by the Gault over most of the area. The present outcrop is evidently near the feather-edge of this formation, for the beds are perhaps nowhere much more than 10 ft. thick, and are in places much less. They consist of coarse, highly ferruginous sands and conglomerates, the latter sometimes containing abundant ill-preserved casts of brachiopods, gasteropods, lamellibranchs and cephalopods. It is probable that the gentle folding in the Jurassic rocks also affects these beds and accounts for their sporadic occurrence. Traces of a synclinal structure are visible in the two detached masses between Corton Manor and Windmill Hill. There are five small outliers resting on Kimmeridge Clay within a few hundred yards of the edge of the Gault, while north of Clevancy and south-west of and north-east of Broadtown Church, Lower Greensand appears for short distances from beneath the overlapping Gault. Elsewhere the Gault rests on Kimmeridge Clay, on a horizon a little below the base of the sands in the Pseudovirgatites Zone near Burderop Wood, and on beds in or just above the top of the *Rasenia mutabilis* Zone near Highway, more and more of the Kimmeridge Clay having been overlapped in a south-westerly direction. Proof of the presence of the *Rasenia mutabilis* Zone near Highway is provided by a ditch-exposure halfway between Highway and Lower End Farm. Here the following fossils were found:—*Involuticeras moeschi* (Oppel), *Exogyra virgula* (Defr.), *Astarte* cf. *ovata* W. Smith. Large specimens of *Protocardia morinica* (de Lor.), also found here, suggest that the overlying Aulacostephanus Zone may be present. This section indicates the extent at this point of the Lower Greensand unconformity as well as of the Gault overlap, as both these formations are so close to the spot that they can rest on only slightly higher horizons of the Kimmeridge Clay.

There are no good exposures of the Gault and no fossils were found. Blue and black micaceous clay is exposed in the streams running out of Highway Gully and Bincknoll Dip. The Upper Greensand, which yields abundant supplies of good water, is about 100 ft. thick between Compton Bassett and Highway. It thins out in a north-easterly direction until it is about 50 ft. thick round Wroughton. The lower part of the formation is nowhere exposed, and is almost everywhere covered by landslips. Its position is indicated roughly by a line of springs and seepages. Exposures of the topmost beds, and particularly of the junction with the Chloritic Marl, are numerous. The best section, showing also 42 ft. of the Lower Chalk, is in a small gorge near Little Town, where 30 ft. of Upper Greensand are exposed.

HENRY DEWEY.

Digitized by Google

2. MIDLAND DISTRICT

T. C. CANTRILL, B.Sc., District Geologist.
C. B. WEDD, B.A. } Senior Geologists.
R. W. POCOCK, B.Sc. }
T. H. WHITEHEAD, M.Sc., A.R.C.Sc. } Geologists.
T. ROBERTSON, B.Sc., A.Inst.M.M. }

During the past season work has been continued in the Wolverhampton Sheet (153) and resumed in the Stafford Sheet (139). In the former, Mr. Pocock has surveyed the main central portion of the Coalbrookdale Coalfield around Madeley, Dawley, and Ironbridge, and has entered the eastern borders of the Shrewsbury Sheet (152) as far as Little Wenlock. Mr. Robertson has completed the revision of the Coal Measures and of the Downtonian and Ludlow rocks in the neighbourhood of Broseley, and has advanced into the Shrewsbury Sheet as far as Barrow and Shirlett Hill.

In Sheet 139 Mr. Whitehead has examined a tract of Upper Coal Measures and Trias lying between Market Drayton, Newport, and Eccleshall.

Cambrian.—Mr. Pocock finds that, east of the Wrekin range, the Comley Sandstone is well exposed at Newhouse Farm, a mile and a half south of Wellington, where it is of the usual greenish glauconitic and micaceous type. It is seen also in an old quarry by the roadside north of Willowmoor, and at the Dairypit, a ridge east of Lawrence Hill.

Silurian.—The Wenlock Shale is exposed in Coalbrookdale and also in Loamhole Dingle, to the north, where it has yielded a characteristic assemblage of fossils, including *Monograptus priodon* (Bronn), *M. vomerinus* (Nich.), and *M. flemingi* (Salt.). These, in the opinion of Miss G. L. Elles, who has kindly examined the specimens, indicate the upper part of the Wenlock Shale. In Loamhole Dingle it is overlain immediately by conglomeratic sandstones of Lower Carboniferous age.

The Wenlock Limestone has been examined at Lincoln Hill on the north of the Ironbridge Gorge and also at Benthall Edge on the south.

Further work by Mr. Robertson on the Downtonian rocks of Linley and Willey shows that, contrary to the statement in last year's Summary, the Ludlow Bone-bed horizon does not crop out in the Linley Brook section. It is exposed, however, in the valley of the Dean Brook, three-quarters of a mile farther north, where a fairly good section is to be seen from about the middle of the Aymestry

Digitized by Google

Limestone to the Downton Castle Sandstone. Between Willey and the Dean the higher part of the Aymestry Limestone is again exposed along the crest of an anticline. Thence to the south-west the Upper Ludlow and Downtonian beds successively appear. Several faults traverse this area in a north-eastward direction. The sequence in the grey Downtonian beds has been worked out and found to agree in essential features with that of the Ludlow type-localities, but on a much contracted scale. The persistence of cornstone bands at definite horizons in the red marls above the Downton Castle beds in the ground lying between Bridgnorth and Much Wenlock is a noteworthy feature. A small area of Wenlock Limestone has been mapped near Benthall and Tickwood.

Lower Carboniferous.—In Lydebrook Dingle, south-east of Little Wenlock, certain conglomeratic sandstones, mapped as Millstone Grit on the Old Series one-inch map (61 N.E.), are well exposed to a thickness of about 70 ft. At Loamhole Pool Mr. Pocock finds that they are underlain by Wenlock Shale and overlain by about 8 ft. of what appears to be a volcanic agglomerate. Higher up the dingle they are succeeded by a bed of limestone, about 4 ft. thick, containing fossils indicative of the Dibunophyllum (D_2) subzone of the Upper Avonian. These Lydebrook Sandstones must therefore be of Lower Carboniferous age, if not older.

At Newhouse Farm, a mile and a half south of Wellington, and also south-west of Willowmoor, some sandstones believed to represent part of the Lydebrook Sandstone Group have yielded fossils that suggest a D_1 age.

Farther to the south the Lydebrook Sandstones have been mapped in Holbrook Coppice, south of the Moors, and westward to Braggers Hill. Here they are overlain by the same limestone bed as in Lydebrook Dingle. This can be seen near the Moors Farm and in the lane at Braggers Hill. What appears to be the same limestone is visible in a lane a quarter of a mile south of Little Wenlock church, where, as elsewhere, it appears to be overlain immediately by basalt or dolerite. At Little Wenlock, however, the main mass of the Carboniferous Limestone clearly rests on the basalt, and its outcrop has been followed westward and northward to the old limestone quarries at the Hatch and Steeraway, where the fauna indicates the D_2 subzone. We have, therefore, evidence of two beds of limestone of D_2 age separated by basalt.

To the south-east of Little Wenlock both limestone and basalt thin out, and at Loamhole Pool the limestone is absent, while the basalt is represented by only about 8 ft. of agglomerate, as mentioned above.

The sandstones exposed to the west of Doseley are believed to pass under the basalt outcrop of Doseley and to belong to the Lydebrook Sandstone Group.

Digitized by Google

The table given below suggests the possible correlation of the Lydebrook Sandstone with the Cornbrook Sandstone of the Clee Hills[1] and the Drybrook Sandstone of the Forest of Dean[2].

Suggested Correlation of the Lydebrook Sandstone.

	Forest of Dean.	Clee Hills.	Wrekin District.
Coal Measures	Upper Coal Measures. *Unconformity.*		Upper Coal Measures. *Unconformity.*
		Middle Coal Measures. *Unconformity.*	Middle Coal Measures. *Unconformity.*
Upper Avonian			Carboniferous Limestone D_2
			Basalt
			Carboniferous Limestone D_2
	Drybrook Sandstone.	Cornbrook Sandstone.	Lydebrook Sandstone (in part D_1). *Unconformity.*
Lower Avonian	Carboniferous Limestone— C ..	Carboniferous Limestone— C?	
	Do. Do. Z ..	Do. Do. Z	
	Do. Do. K ..	Do. Do. K	
	Old Red Sandstone.	Old Red Sandstone.	Wenlock Shale.

Coal Measures.—The sandstones overlying the Carboniferous Limestone at Steeraway, the Hatch, and Huntington, and represented as Millstone Grit on the Old Series map, Sheet 61 N.E., are believed to be comparable with the so-called Millstone Grit of Lilleshall, which is unconformable to the Carboniferous Limestone.[3] The Lilleshall sandstones are regarded as the basement-beds of the Middle Coal Measures, and there appears to be no evidence that the true Millstone Grit occurs anywhere in the Wrekin area.

The Middle Coal Measures include practically all the profitable seams of coal. They lie in two distinct basins, one north-west and the other south-east of the supposed north-eastward prolongation, beneath the newer rocks, of the Wenlock Limestone escarpment of Lincoln Hill. The Middle Coal Measures are covered unconformably by the Upper Measures, the plane of denudation between them being known as the Symon Fault. They consequently vary in thickness in different parts of the basins, being thickest towards the centres, where the higher coals are present. The average thickness of the Middle Coal Measures lies between 150 and 300 ft.

The lower part of the Upper Coal Measures consists of about 100 ft. of red marls and brown sandstones (including the Rough Rock),

[1] Dixon, E.E.L., *Trans. Roy. Soc. Edin.*, vol. li, 1917, p. 1064.
[2] Sibly, T. F., *Geol. Mag.*, 1912, p. 417.
[3] 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*), 1924, p. 45.

Digitized by Google

followed by a group, about 500 ft. thick, of grey sandstones with subordinate shales, marls, and thin coals; but no definite separation of them into the Etruria Marl and Newcastle (Halesowen) groups has been found practicable. Just below the top of these doubtful beds some dark reddish-brown sandstones west of Hay Farm, near Coalport, contain numerous pieces of fossil wood, but the material is not well preserved.

The beds described above pass upward into red sandstones and marls of a definitely Keele type, and these are succeeded on the eastern side of the coalfield by red marls with calcareous dull-red sandstones and conglomerates, which are referable to the Enville Beds.

South of the Severn Mr. Robertson finds that the truncation of the productive (Middle) Coal Measures by the Symon Fault at the bottom of the barren (Upper) measures culminates south of Broseley in complete disappearance of the former along a line drawn approximately from Linley to Caughley Old Hall. The only recent information about the strata is that to be obtained from the various tile-works, which obtain their clay in some cases from the beds above the Symon Fault.

In the Stafford Sheet parts of the inliers of Keele Beds near Adbaston, Cheswardine, and Hinstock have been surveyed by Mr. Whitehead, who finds that good sections are scarce. Near Adbaston Farm some disused quarries show reddish-brown thick-bedded sandstones; but judging from the soil and the shallow sections, red marls predominate. The best exposure is that afforded by a cutting[1] on the Shropshire Union Canal, which, beginning at the Market Drayton road about one and a quarter miles west of Cheswardine, runs north-westward towards Market Drayton. Here the Keele Beds are brought up by a shallow anticlinal fold, apparently pitching towards the south-west. The beds consist mainly of purple marls, with fairly thick but lenticular beds of red and purple sandstone, and, in places, some conglomeratic cornstone. A search for Spirorbis limestone did not meet with success. Except for the southern 500 or 600 yds., however, the section is much overgrown and obscured, and it is estimated that the thickness of beds well exposed does not exceed 100 ft.

At Wood Farm, a mile north-north-west of Adbaston, a hard calcareous breccia, with pebbles of quartz and of chert, for the most part angular or subangular, was found. Associated with it there are beds of hard sandstone, probably also calcareous. These beds of sandstone and breccia immediately underlie the Bunter Pebble Beds, and it is just possible that they may be the basement-bed of that formation; but more probably they should be grouped with the Keele Beds. They may, perhaps, represent a remnant of the Calcareous Conglomerate Group of the Enville Beds. Somewhat similar rocks were seen by Mr. Whitehead near Oldsprings, two

[1] Hull, E., 'The Triassic and Permian Rocks of the Midland Counties of England' (*Mem. Geol. Surv.*), 1869, pp. 47, 48; also W. Gibson in 'Summary of Progress' for 1900 (*Mem. Geol. Surv.*), 1901, p. 103.

Digitized by Google

miles south-east of Market Drayton, in ground surveyed some years ago by Dr. Gibson.[1]

Trias.—The Keele Beds near Cheswardine, Adbaston and Hinstock, in the ground surveyed by Mr. Whitehead, are overlain unconformably by the Bunter, usually by the conglomerates and pebbly sandstones of the Pebble Beds. Red sandstone, devoid of pebbles, which may be regarded as the Lower Mottled Sandstone, appears sporadically at the base of the Bunter. Near Great Sowdley this non-pebbly sandstone has an extensive outcrop.

The Pebble Beds extend southward from Goldstone Common to Hinstock, Sambrook and Calvington ; the Lower Mottled Sandstone appears from beneath them at Hinstock. In places the Pebble Beds take the form of pebbly, rather hard sandstones, in which the pebbles, though numerous, are rarely in contact. This condition was seen in the south end of the canal-cutting near Cheswardine. Elsewhere the formation consists of semi-coherent shingle interbedded with sand-rock ; the pebbles in the shingle are massed together, and in consequence are much bruised and pitted. This condition was observed in some gravel-pits near Cheswardine and on Goldstone Common.

A fault ranging northward from Adbaston by New Inn Bank and along the Langot Valley (east of Bishop's Wood) to a point about a mile north of Broughton, throws down the Keuper Marl, Lower Keuper Sandstone and Upper Mottled Sandstone on the east, against the Bunter Pebble Beds, Lower Mottled Sandstone and Keele Beds on the west. The Upper Mottled Sandstone consists chiefly of the usual brick-red and mottled sandstones, though buff sandstones were seen in places. East of the fault just mentioned the outcrops of the Upper Mottled Sandstone, the Lower Keuper Sandstone and in places the Keuper Marl are repeated by a number of strike-faults coursing nearly north and south. Just north of the River Sow, near Bishop's Offley, the outcrop of the base of the Lower Keuper Sandstone is repeated seven times along a west-to-east line.

At New Inn Bank the beds near the base of the Lower Keuper Sandstone consist of coarse sandstones, calcareous and pebbly, in which a large proportion of the fragments are angular or subangular. These coarse beds die out northward and eastward. Below them a bed of dull-purple sandy marl, from 6 to 10 ft. thick, has been worked in many places by means of adits driven under the sandstones.[2] Farther east the Lower Keuper Sandstone crops out near Standon. Here neither the marl-band nor the coarse beds have been seen.

The passage of the Lower Keuper Sandstone into the Marl above is gradual, taking place by the alternation of flaggy sandstones with sandy marls, until marls prevail. These transition beds, which are well seen near Woodwall Green, three miles north-west of Eccleshall, may be regarded as representing the Waterstones.

---

[1] Gibson, W., *loc. cit.*
[2] Hull, *op. cit.*, p. 72.

Digitized by Google

Igneous Rocks.—Mr. Pocock finds that further study of the basalt or dolerite of the Coalbrookdale district necessitates some modification of the statements previously made regarding its field relations.[1]

Evidence is accumulating that suggests that the igneous rocks are, at any rate in part, contemporaneous with the Carboniferous Limestone. It will be possible to form more definite conclusions on this point when the rocks have been examined petrographically.

At the Hatch and Little Wenlock the basalt underlies the main bed of Carboniferous Limestone ; but near the latter place it appears to be underlain by a thin bed of Carboniferous Limestone. In Lydebrook Dingle again the basalt rests on a thin bed of Carboniferous Limestone and is succeeded immediately by Middle Coal Measures strata, the main upper limestone bed being absent. At the Doseley quarry both limestone beds appear to be absent ; but the basalt is believed to rest on the equivalent of the Lydebrook Sandstone, which, in the dingle, lies immediately below the lower limestone bed. At Doseley the basalt is succeeded by Middle Coal Measures sandstone. At the Horsehay quarry the base of the basalt is not seen, but the igneous rock is succeeded by Middle Coal Measures.

Glacial and Post-Glacial.—In the ground surveyed by Mr. Pocock, sandy drift occurs at Madeley, being exposed in a pit at Hill's Lane, where it is overlain by from 4 to 10 ft. of boulder-clay, as described by Dr. L. J. Wills.[2] Here the drift must be banked up against a very steep slope ; for in the adjoining field 100 yds. to the south-east, and at a higher level than the top of the section in the sand-pit, the Keele Beds are exposed. The Madeley Fault is believed to pass between these two sections, and may be responsible for the steepness of the slope against which the drift is banked.

Boulder-clay covers all the high ground to the west of Madeley, and can be seen to a thickness of from 15 to 30 ft. at Lloyd's Coppice, along the top of the cliff overlooking the Severn valley.

A pit at the Brockholes east of Madeley Union Workhouse shows boulder-clay resting on coarse sand. Here the material consists largely of Carboniferous sandstones and shales, with a few granites and fragments of slaty rocks.

The drift at Lincoln Hill, described by Dr. Wills,[3] is now somewhat obscured ; but about 10 ft. of fine red-brown sandy loam with some laminated layers can be seen resting on and against massive Coal Measures sandstone. Very similar silts occur in a section about 100 yds. north of Moor Farm, Lightmoor, where they appear to form merely a lenticle in the boulder-clay and Glacial sand. Here the drift is at least 60 ft. thick.

A small patch of gravelly drift, a little over 300 ft. above O.D., occurs about 200 yds. east of the old mill at Ironbridge.

---

[1] ' Summary of Progress ' for 1923 (*Mem. Geol. Surv.*), 1924, p. 48.
[2] *Quart. Journ. Geol. Soc.*, vol. lxxx, 1924, pp. 283, 284.
[3] *Op. cit.*, pp. 281, 282.

Digitized by Google

A buried channel filled with sand has been proved in the tile-clay workings north of Lightmoor Station. It has a south-easterly direction and may be the pre-Glacial course of the Horsehay Brook. At its south-eastern end it bends to the east into alignment with the Lightmoor valley.

On the high ground of Little Wenlock and Coalmoor the drift is very thin. Boulder-clay occupies the flat ground round Willow-moor at about 660 ft. above O.D.; it is being trenched by the small stream that flows through the gap between the Wrekin and Lawrence Hill.

Mr. Robertson finds that the plateau of Broseley and Barrow is mainly free from Glacial drift. Patches of gravel occur in several places, e.g., at the Hangster's Gate, Willey, at Dean Corner, and around Posenhall and Wyke. At the last two localities the gravel is associated with a spread of boulder-clay. Small patches of gravel also lie on the edge of the Severn gorge above Tuckies, at a height of about 400 ft. above O.D. Most of these occurrences have recently been noted and discussed by Dr. Wills in the paper already mentioned.

Mr. Whitehead finds that, south of Cheswardine and near Little Sowdley, there are patches of a rather stiff clay containing many pebbles; but the characters of the deposits have to be inferred from soil-indications and shallow exposures. A considerable area about Hinstock, Ellerton, and Goldstone is covered with a deposit of sandy red clay containing a fair number of pebbles, some of which were derived from far outside the district. This deposit breaks down into a rather sandy soil. In places it appears to pass into definitely sandy and gravelly drift. A somewhat similar sandy clay covers the low ground south of Offleyhay. Here also knolls of sand and gravel occur near Garmelow.

The bottom of the Langot valley is covered with sandy and gravelly drift, which, at the south end, is banked against and surmounts the watershed between the River Sow and the streams belonging to the Severn drainage system. Between New Inn Bank and Bishop's Wood this watershed is about 60 ft. above the flood-plain level of the River Sow in the Langot valley. This accumulation of gravelly drift, and a fan-like spread of similar material farther west, near Doley and Lipley, are possibly portions of one or more delta-form deposits, marking a pause in the retreat of the ice-front, and are perhaps related to the linear series of esker-like deposits recognised by Mr. Dixon[1] as extending from Knighton to Littleworth. Near New Inn Bank the River Sow makes a sharp turn to the east and enters a narrow gorge-like valley; and from here to Cop Mere its valley has a juvenile character and contains no alluvium except such as has been produced by the damming up of the stream to form mill-pools. If seems possible that this juvenile valley originated as a marginal overflow when the ice-front lay in the neighbourhood.

[1] 'Summary of Progress' for 1920 (*Mem. Geol. Surv.*), 1921, pp. 19, 20.

Digitized by Google

The late-Glacial or early post-Glacial sands and gravels noted by Mr. Robertson[1] in the Sow valley north of Stafford have been traced by Mr. Whitehead to and beyond Eccleshall. Down stream from Eccleshall they have a markedly terrace-like form. Above Eccleshall this form is less apparent, though on the south side of the river there is a well-marked bench at a height of about 300 ft. above O.D. formed of these sands, from which the bare Keuper Marl rises in a steep bluff. North-west of Eccleshall the main mass of the sands and gravels extends up Brockton Brook. Small 'islands' of the sands rise from the peaty and alluvial flats of the River Sow. Of these the most conspicuous is that upon which Eccleshall Castle stands. The water-supply of Eccleshall is derived from these sands.

About half a mile north of Brockton Hall, Brockton Brook is bordered by a well-marked terrace 3 to 4 ft. above the present flood-plain. In continuity with this terrace a broad flat extends from Brockton Hall to Slindon, near which village it again assumes the form of a terrace, 3 to 4 ft. above the flood-plain of Meece Brook. The broad flat perhaps marks a former course of Brockton Brook eastward to Meece Brook instead of southward to the River Sow. On this hypothesis, however, the present course of Brockton Brook must represent a return to a still earlier course, for it is its present course that the late-Glacial sands and gravels follow.

T. C. CANTRILL.

[1] 'Summary of Progress' for 1920 (*Mem. Geol. Surv.*), 1921, p. 21.

Digitized by Google

3.—YORKSHIRE DISTRICT

C. N. BROMEHEAD, B.A., District Geologist.
G. V. WILSON, B.Sc., Senior Geologist.
D. A. WRAY, M.Sc.
J. V. STEPHENS, B.Sc., B.Eng.
WILFRID EDWARDS, B.A.
} Geologists.

Mr. Wilson has practically finished his work on the Concealed Coalfield, and his memoir and two colour-printed sheets of vertical sections should be published shortly. The remainder of the staff have continued field work in the Huddersfield Sheet (77). Owing to delay in getting the York office ready for occupation Messrs. Stephens and Edwards have remained in the field to the end of the year and have made good progress on the northern part of the area; field work for this Sheet should be completed before the end of the next field season.

Millstone Grits.—The mapping of the Millstone Grits has been completed, the moorlands south and west of Huddersfield being surveyed by Mr. Wray, who has also paid numerous visits to two important borings near the town; these have been carried into the Kinderscout Grit and show the complete sequence of the Millstone Grits in the district. He finds that in the Colne valley a fairly complete sequence is exposed: between the several bands of grits he has discovered marine horizons which can be traced over wide areas and aid considerably in the correlation of the beds and consequently in the elucidation of the geological structure. When the fauna of these beds has been studied in detail it will be possible to make a close comparison with the adjoining areas and also to attempt a correlation with the succession on the Lancashire side of the Pennines.

Generally speaking the beds have a gentle and fairly uniform dip to the east. The Kinderscout grits cover a large area to the west of Pule Hill; but the beds are affected by several powerful N.N.W.-S.S.E. faults, so that in the neighbourhood of Marsden the Kinderscout Grit is only seen in the bottom of the Colne valley; minor folds combined with faulting result in its reappearance in the Deanhead valley, at Firth House Wood to the east of Krumlin, and also in the Colne valley, in Merry Dale Clough to the west of Slaithwaite.

A very distinctive marine band is everywhere met with close above the Kinderscout Grit. It is usually several feet thick, and crowded with impressions of goniatites, so that it is easily located wherever sections occur. At Pule Hill and in the country to the west of Marsden and Rishworth it usually consists of two bands separated

Digitized by Google

by about 30 ft. of black shale. In the borings at Huddersfield, however, the two bands appear to have coalesced and to be represented by about 20 ft. of sooty black shales crowded throughout with goniatite impressions.

In last year's Summary attention was called to the presence of a thin band with *Lingula* occurring between the flaggy Upper Kinderscout Grit and the lower massive grit, which appeared to have a wide range when followed along the outcrop of these beds.[1] The boring at Huddersfield, which is eight miles east of the nearest exposed section of this particular band, reveals its presence at the same horizon, under exactly similar conditions at a depth of 1,440 ft. from the surface. The absence of goniatites suggests that it probably represents an estuarine rather than a marine incursion. Its wide range is, however, noteworthy.

The two most persistent members of the Millstone Grits are the Kinderscout Grits at the base and the Rough Rock at the top. These are everywhere present and readily recognised. Between these two beds is a series of varying grits with intervening shales which we have termed the Middle Grits. Throughout the greater part of the area, four distinct beds of grit can be recognised. These were termed respectively in descending order the A, B, C and D grits by Professor Green in the original survey of this area.[2] In the neighbourhood of Slaithwaite all these beds are exposed and their lithology and relationships can be examined in detail. The beds B and D around Slaithwaite and Holt Head contain much ganister, for which they have been worked in the area immediately to the south. To the north, at Wholestone Moor and in the Ryburn valley, the ganister is completely absent from both horizons, while no signs of ganister-rock were observed in these beds in the deep borings made at Huddersfield.

The intervening grit band C (often termed the Main Third Grit) is everywhere a massive bed, and has been largely quarried. It constitutes the massive grit capping Pule Hill, and also forms a remarkable wall-like escarpment at Buckstones Hill; its development to the north was described last year under the name 'Midgley Moor Grit.' In the deep boring made on the east side of Huddersfield it has, however, apparently lost its massive nature and contains many shaly partings. It has also dwindled considerably in thickness, and affords poor prospects as a source of underground water-supply.

The uppermost bed of the Middle Grits, termed A, is probably the most variable member of the series. In its most westerly exposures it largely consists of flags. Around Golcar it constitutes a fairly firm gritty sandstone which was formerly somewhat extensively quarried under the name of 'Huddersfield White Rock.'

[1] 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*) 1924, p. 53.

[2] Green, A. H., 'The Geology of the Yorkshire Coalfield' (*Mem. Geol. Surv.*), 1878, p. 48.

Digitized by Google

To the east, however, it thins away rapidly and in the borings around Huddersfield consists of two thin bands of sandstone, not exceeding 15 ft. in thickness, separated by about 15 ft. of shale. A coal and a marine band always overlie the 'Huddersfield White Rock' and enable one readily to recognise this horizon. The considerable attenuation of the Middle Grits eastwards is a factor that ought to be clearly borne in mind in any proposed deep borings for water. These beds cannot be relied on to yield any copious amount of underground water in the Huddersfield district, and unless a sufficient supply can be obtained from the Rough Rock it will usually be necessary to go through the entire Middle Grit Series into the Kinderscout Grit.

The Rough Rock, as has been already stated, is perhaps the most readily recognised member of the Millstone Grit Series owing to its fairly uniform nature and development. Elland is largely built on the dip slope of this rock, while immediately to the south its outcrop is considerably shifted by a somewhat complex fault system. The village of Stainland also is situated on an outlier of the Rough Rock, which is completely cut off south of the village by a series of powerful east-and-west faults. It reappears, however, at Lindley Moor and forms a well-marked escarpment at Longwood Edge and Crosland Moor on either side of the Colne valley. Everywhere it has been extensively quarried, but the majority of the quarries are now in disuse or only worked intermittently, with the exception of a group on Crosland Moor and Greetland Moor. At Crosland Moor, where some of the beds consist of a rather hard freestone, it is still extensively wrought and under the name of 'Crosland Hill Stone' is sent away for building purposes to many Yorkshire towns and also more distant centres. Only certain impersistent bands are of economic value. Much of the material quarried can only be employed locally for walling, or other rough purposes.

At the base of the Rough Rock there is usually a bed of flags which sometimes attains sufficient importance to be of economic value. Green[1] mentions the great development of this 'Flagstone Rock' in North Dean Wood, north of Greetland, but between the Calder valley and Illingworth he was unable to trace a line of subdivision between this part of the bed and the coarse grits above for any distance and mapped the two as a single bed. They have now been separated: in North Dean Wood and over Greetland Moor there is a parting between them consisting of about 4 ft. of brown and blue micaceous mudstone with obscure plant remains. It is also seen in Bankhouse Wood on the opposite side of the Calder; on Warley Common this bed is 6 ft. thick, but it thins out eastwards. Along Rake Bank north of Wheatley it is 2 to 4 ft., but in the railway cuttings between Copley and Halifax coarse massive grit rests directly on flagstones, and in the northern part of Halifax Mr. Edwards

[1] *Op. cit.*, p. 63.

Digitized by Google

finds the distinction becoming less marked. Between Exley and Elland it hardly exists, and there is a passage from true flags through sandstones and flaggy grits to the massive beds. Here, however, the whole series disappears beneath the Lower Coal Measures.

Now that Mr. Bisat's work on the goniatites of the Millstone Grits has been published,[1] the examination of the numerous specimens collected by the field-staff and by the fossil collector from the various marine beds can be put in hand. Those from the two borings in Huddersfield will provide a useful check on the sequence, and the correlation of the many exposures can be definitely settled.

Lower Coal Measures.—Over a part of the area the complete sequence of the Lower Coal Measures has been studied, the Middle Measures having been reached by Mr. Edwards around Birkenshaw and Drighlington. He finds the average thickness of the Lower Coal Measures to be 1,170 ft. • The general sequence is well known; the Elland Flagstones are extensively worked for stone; below them the fireclays are of more importance than the accompanying coals, but above them the Black Bed and Better Bed Coals are of great value. Largely owing to the courtesy of the firms working these various seams some interesting facts have been added to our knowledge. The coal lying immediately above the Rough Rock, the Belper Lawn Coal of Derbyshire and Six Inch Mine of Lancashire, is everywhere present and is succeeded by a marine band; this band has been detected in the little faulted outlier of Coal Measures at Salterhebble, shale with goniatites being found in the upper railway cutting. This outlier was shown on the original map (88 N.E.), but a similar one farther north, near the Halifax Infirmary, has now been added, largely on the strength of sections recorded many years ago in the 'Halifax Naturalist,' though the boundary fault is readily traceable on the eastern side of the Hebble valley.

Mr. Stephens has detected the marine band at the southern corner of Thornton Moor Reservoir and at the Holmfield entrance of the Great Northern Railway tunnel at Queensbury; at the latter the section is as follows:—

	Ft.	in.
Black shale (Marine band)	0	4
Grey decomposed shale	2 to 3	0
Coal	0	2
Bastard ganister	0	4
White and yellow clay	3	0
Coarse grit		

Mr. Wray notes that the fireclay was formerly worked at Salendine Nook, near Huddersfield; the section at Elland Station is well known.

The fossils from surface exposures of this bed are badly preserved, but two borings have afforded more satisfactory material; at Brook-

[1] 'Carboniferous Goniatites of North of England and their Zones,' *Proc. Yorks. Geol. Soc.*, vol. xx, 1924, pp. 40–124, Plates I–XI.

Digitized by Google

foot, near Brighouse, there are 2 ft. of dark shale with goniatites, identified by Mr. Bisat as *Gastrioceras subcrenatum* (Schlotheim), *Pterinopecten*, etc., below which is 1 ft. of shale with fish remains resting on 6 in. of coal; the fireclay is 2½ ft., fine micaceous sandstone 8 ft., and then coarse grit. At Britannia Mills, Bradford, the marine band extends through 4 ft. of black shale from which Mr. Stephens obtained *Lingula* as well as the usual lamellibranchs and goniatites and also a single specimen of a small gasteropod. The boring at Brookfoot is also interesting as revealing more numerous *Carbonicola* bands than have been detected at the surface; they occur short distances below the Soft Bed, Middle Band, 36-Yard and 80-Yard coals.

The sandstones in the Ganister Coal Series are very variable. Mr. Stephens finds that south-east of Soil Hill they are practically non-existent. At Soil Hill the Middle Band stone begins to develop and can be traced in a north-westerly direction, capping Cock Hill on the main Halifax-Keighley road, Foreside Top and Whinny Hill to the east of Leeming. The 36-Yard Band stone appears to develop in the same direction: absent along the escarpment of Lower Coal Measures as far north as Soil Hill, it is exposed in Stubden Beck as a massive fine-grained sandstone, 8 ft. thick, and also along Denholme Edge, where it has an average thickness of 6 ft. To the east it thins, being reduced to a few thin flaggy bands at Egypt, while at Cocking Lane clay-pit south-east of Thornton it has completely given way to shales. The '60-Yard Quarrel' is of importance first at Soil Hill, of which it forms the top; farther north the area between Denholme Edge and Stubden Beck is mostly covered by this rock, which is 40 ft. thick. On the opposite side of the Denholme Beck valley the area north of the Egypt fault is also occupied by the 60-Yard Quarrel; it is, however, coarser and contains bands of coarse grit. On Harrop Edge the Quarrel is dipping due east at about 5 degrees and disappears under the overlying shales and flags near Shay House. The 80-Yard Coal and rock is exposed in Shibden Dale, and also recorded from the boring at Britannia Mills, Bradford, where it is only 128 ft. above the Hard Bed Coal. A band of *Carbonicola* is also recorded here from the shales just above the 80-Yard Coal.

Farther south Mr. Edwards notes that irregular sandstone bands appear here and there beneath the Soft Bed and the 80-Yard Coals; the latter can be traced all round the valleys between Halifax and Brighouse. Mr. Wray finds that the coal disappears somewhere immediately to the east of Elland; the rock occurs as a thin flaggy band overlain by a little fireclay at Ainley Top. On the other hand the Soft Bed or Huddersfield Flags become locally important in that area. They are absent immediately north of Elland but appear at Lindley and rapidly increase in thickness to a maximum of over 100 ft. at Gledholt, to the west of Huddersfield. Here they consist of thin, strongly false-bedded flaggy sandstones with in-

Digitized by Google

constant shale partings. They are represented in the extreme south of our area at Honley but are considerably thinner. The Soft Bed Coal has been worked over the greater part of the district, and a thin *Carbonicola* band occurs about 12 ft. above it. The Middle Band Coal is always present but never of sufficient thickness to be worth working. Much of the town of Huddersfield is built upon the Middle Band rock which makes a slight escarpment on the west side of the town. The ganister and fireclay associated with the Halifax Hard and with the 36-Yard coals are being actively worked, as are the excellent flags in the lower part of the Elland Flags Series, which form very conspicuous scarps. In the eastern part of the area they are of some value as a source of underground water-supply. The upper flags are of comparatively little value, but the intervening shales are used for brickmaking.

In the north Mr. Stephens finds a sandstone between the Elland Flags and the Better Bed Coal. It is split by a shale band containing a thin coal and seat-earth which is persistent over the whole area mapped by him. It is to be seen round the top of Bowl Shaw Clough and the eastern side of Upper Stubden Dale and reappears to the north of the Bailiffe Bridge fault from Old Dolphin, round through the Reservoir to Horton Bank; at the Reservoir the coal is less than an inch thick and the clay about 3 ft., resting on 7 ft. of grey shale with ironstone nodules mainly congregated 3 ft. below the coal. In the brickyard at Fairweather Green, north-east of Clayton, the coal varies from a half to four inches.

The Better Bed and the Black Bed coals are extensively worked by the Low Moor Iron Company. Their plans, to which we were given full access, are particularly useful in elucidating the structure of the area east of Bailiffe Bridge and Brighouse. As a rule the important faults running north-north-west to south-south-east appear to throw those at right angles to them, though here and there the action seems to be reversed. An interesting washout in the Black Bed at Hartshead Colliery was visited.

Mr. Edwards has done much work on the complex series of coals known as the Beeston, Churwell, Shertcliffe, etc. The Shertcliffe Bed becomes a stone coal (Popplewell) near Scholes and Bailiffe Bridge, the roof yielding fish remains. Mr. Stephens saw an excellent section of the various thin coals and measures between the Crow Coal and the Oakenshaw Rock at present exposed in the Bradford Brick and Tile Company's yard at Haycliffe Hill; the following details were obtained:—

		Ft.	in.
Oakenshaw Rock	Massive gritty sandstone, much jointed	15 0 to 20	0
	Grey shale	4	6
	Coal	0 4 to 0	6
	Hard bastard ganister	2 0 to 2	6
	Soft grey seat-earth with ironstone nodules	2	3
	Sandstone	1	3
	Grey mudstone with ironstone nodules and 'duck eggs'	16	0
	Black brittle shale	4	0

Digitized by Google

		Ft.	in.
32-Yard Coal	.. ..	0	7
	Black carbonaceous shale .. .. 0 8 to	0	10
	Soft seat-earth	2	6
	Alternations of thin sandstone, shale and mudstone with many ironstone nodules near the base ..	23	6
	Shale with nodules and thin bands of ironstone ..	4	0
22-Yard Coal	.. ..	touched	

Middle Coal Measures.—Mr. Edwards has mapped some 750 ft. of these beds. In his area the Blocking Bed has been worked but it is poor and usually under 2 ft. thick. The Middleton Main, Brown Metal Coals, Adwalton Black Bed and Adwalton Stone Coal, and in most places the Middleton Little Coal, are good seams and have been worked out over much of the ground. The Middleton Main is often over 4 ft. thick. In a new working at Cockersdale it is 4 ft. 6 in. thick, and is recorded as 5 ft. thick in the shaft at Morley Main. It crops out in the western end of Gomersal Tunnel, where a *Carbonicola* band was seen in its roof. The Middleton Little Coal is thin where it outcrops round Gomersal, being only 8½ inches at the eastern end of Gomersal Tunnel. It thickens eastward, 16 inches of coal (probably not quite the full thickness) being seen at Birstal, and 25 inches in the shaft at West End Colliery, Batley. It is recorded as 2 ft. 9 in. and 3 ft. thick in the shafts at Bruntcliffe and Morley Main respectively. From these pits it has been worked over a wide area. Near Birkenshaw Bottom a bed with *Carbonicola* and Ostracods was seen a few feet below the coal.

The First and Second Brown Metal coals both vary in thickness about an average of 2 ft. They are 36 ft. apart at Morley, but come closer together to the west, until at Howden Clough, Adwalton and Upper Batley they have united to form one bed, or more usually a group of beds separated by thin partings of dirt and sandstone. In this bed, called the Two Yards or merely the Brown Metal bed, there is usually more than 3 ft. and locally as much as 9 ft. of coal. It covers very little area, however, as the junction of the two seams is not far from the outcrop, and most of the intervening space is occupied by a large washout. This washout is in places over a mile wide, and as far as can be seen in the small area mapped takes a north-west to south-east course. It is filled by the Birstal Rock, which is over 80 ft. thick at its maximum, and has been quarried on a large scale in the neighbourhood for building-stone. The rock is false-bedded and variable, and the basal beds, exposed in the cutting near Upper Birstal Station, are conglomeratic, pebbles of coal being common. It appears to die out a short distance beyond the limits of the washout. The Brown Metal Coal is thickest close to the washout, and has been seen with interbedded sandstone under these circumstances near Howden Clough and at Smithies.[1] The Adwalton Black Bed and Adwalton Stone Coal are good seams, but, occurring beneath little thickness of strata in

[1] 'Geology of the Yorkshire Coalfield' (*Mem. Geol. Surv.*), 1878, p. 293.

Digitized by Google

the area mapped, are nearly worked out. *Carbonicola* beds occur in the roof of both these seams. The Thornhill Rock provides excellent building stone, quarried south of Morley.

Pleistocene.—Glacial beds occur in the Calder valley, but are mostly concealed beneath the alluvium. At Copley a patch of boulder-clay extends as far north as the railway, sections seen when the school was built being recorded in the 'Halifax Naturalist' for 1904; traces of boulder-clay are also known in the Hebble valley. At Holmfield a little north of the station Mr. Stephens has mapped a patch of drift material banked against the scarp of the Illingworth fault. These apparently contain boulders of more or less local origin only, but in the gravels beneath the alluvium of the main river foreign stones are common. Mr. Wray was fortunate to see a deep excavation at the Elland Sewage Works; the gravels appear to have been deposited under water and are probably best described as of fluvio-glacial origin. Lake District volcanic rocks and granites occur abundantly in subangular and rounded boulders ranging in size up to 3 ft. across.

Of a very similar nature are the deposits occurring in the steep-sided cloughs known as Badger Gate Clough and Bradley Clough on the southern side of the Colne valley at Slaithwaite. Here a very coarse gravel covers most of the valley floor, and many of the boulders, all of local rocks as far as can be judged, are subangular and little rolled. Similar coarse gravels have also been seen in the Holme valley at Honley, while Dr. T. W. Woodhead has described a similar series of gravels at Dalton in the immediate vicinity of Huddersfield itself.[1] A section showing these coarse gravels, about ten feet thick, and resting on soft Lower Coal Measures shales is still exposed in the Huddersfield Brick Company's brickyard at Hillhouse, where they occur about 100 ft. above the present level of the river valley. Though some of these deposits have been claimed to be of directly glacial origin, they are more probably, like the Elland gravels, the products of extensive meltwaters at the close of the Glacial Period and consequently best referred to as fluvio-glacial or late glacial flood gravels.

A similar origin may be suggested for the isolated patch of gravel at Castle Hill in Kirklees Park. This lies at a height of about 300 ft. above O.D. and is seen to a depth of about 10 ft.; the structure is tumultuous and blocks of sandstone occur up to 2 ft. in greatest length.

Mr. Stephens has also investigated the glacial phenomena of a part of the Aire valley; as the area lies outside the margin of the one-inch map his results are given in some detail:—

The advance of the Airedale glacier in a south-easterly direction caused the damming of the tributaries to the south of the main Aire valley, and the formation of a series of lakes along the margin

[1] Woodhead, T. W., '*Naturalist*,' 1917, pp. 219–232.

Digitized by Google

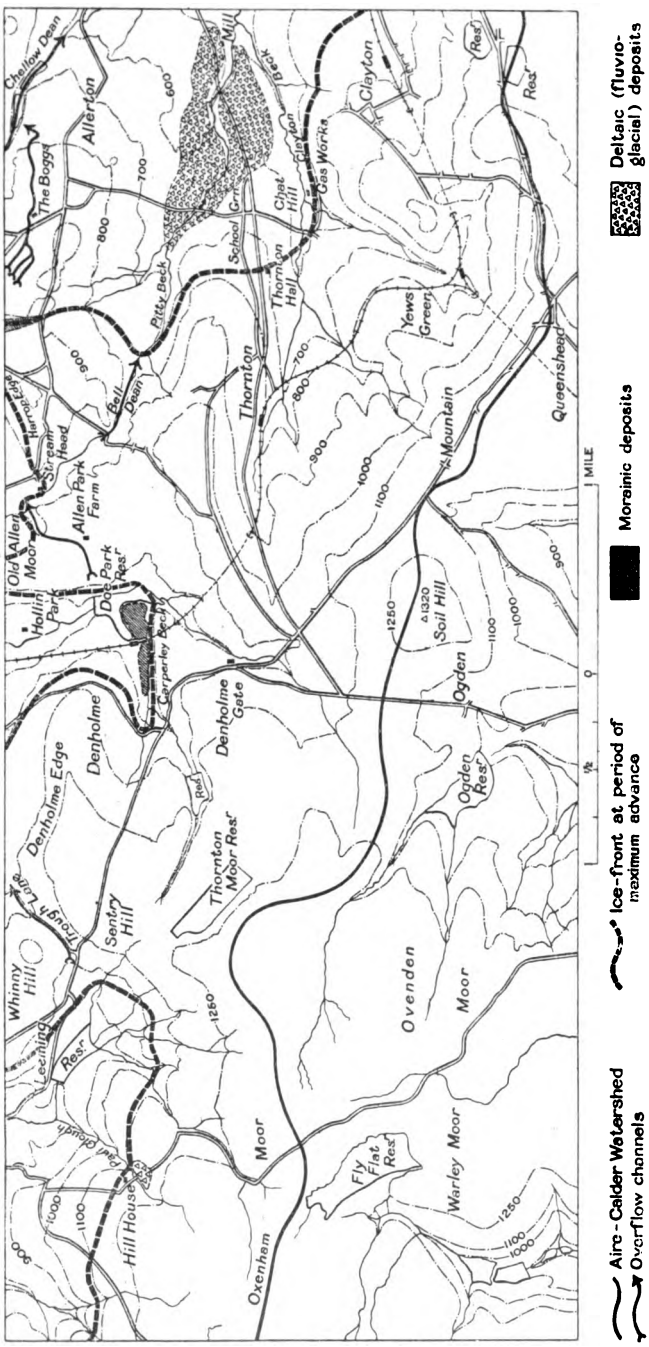

FIG. 1.—*Map of the Glacial phenomena west of Bradford*

(Note: For 'Oxenham' read 'Oxenhope,' for 'Queenshead' read 'Queensbury,')

Digitized by Google

of the glacier against the higher ground of the Aire-Calder watershed. Messrs. Jowett and Muff[1] have worked out in detail this system of marginal lakes, their varying levels and corresponding overflow channels, from the Worth valley to Wibsey where the Airedale glacier first succeeds in crossing the Aire-Calder divide into the Spen valley.

The area considered here consists of a narrow wedge-shaped strip of the southern part of this glaciated area from Oxenhope to Allerton and Clayton, and includes parts of the sites of the Oxenhope, Harden valley, Stream Head, Cottingley valley, and Bradford Lakes of the above-mentioned authors.

In the Oxenhope valley typical boulder-clay extends as far southwards as the upper end of Leeming Reservoir. A trial hole bored for the reservoir dam encountered the following succession :—

	Ft.	in.
Soil	0	9
Stony yellow clay	6	0
Stony blue clay	9	0
Fine blue clay	27	0
Fine silt	0	6
Gravel	6	0

The hillsides to the south of Oxenhope are devoid of boulder-clay, except for a few small patches on the lower slopes as at Farther Isle (975 ft. above O.D.).

Higher up a thin gravelly drift containing a few limestone and chert pebbles occurs sporadically up to an altitude of 1,100 ft. This seems to have been the highest point reached by the ice along these hillsides; a possible exception being made to account for a water-worn gravel deposit of local material which occurs between 1,140 ft. and 1,200 ft. at Hill House (Fig. 1) on Paul Clough. This seems to point to a slight local advance of the ice-front.

The maximum level of the Oxenhope Lake was determined by the initial height of its outlet, the col between Whinny and Sentry Hills. This originally stood about 1,050 ft. but was cut down to 1,020 ft. before being deserted. This Trough Lane channel was above the ice range and only became disused through the retreat of the ice front uncovering an outlet at a lower level. On the Harden valley side it issues into a very shallow valley running parallel to Denholme Edge.

Evidence of ice trangression is not met with until just above the 950 ft. contour. Below this level boulder-clay covers most of the valley but is very variable in thickness—from a mere skin to 30 or 40 ft.; this latter depth is reached in a long low mound running parallel to the beck at Hollin Park. To the south the boulder-clay terminates abruptly at the east-and-west valley of Carperley Beck (Fig. 1) forming a local terminal moraine—a long narrow ridge to the west and a large mound over 60 ft. high to the east of Denholme

[1] Jowett, A., and H. B. Muff, 'The Glaciation of the Bradford and Keighley District' *Proc. Yorkshire Geol. and Polytech. Soc.*, vol. xv, 1904, pp. 193–247.

Digitized by Google

Station—composed for the most part of pebbles and cobbles in a plentiful sandy matrix; shale pellets are common and boulders more frequent on the east side; limestone pebbles of several types and chert also occur. Upstream from this moraine a thin patch of gravelly drift exists in the valley 300 yds. east of Stubden Reservoir at 925 ft. above O.D., and similar patches occur along the sides of the Denholme Beck valley between the station and Denholme Gate, at 875 ft. and 900 ft. These have possibly been carried to their present sites by masses of ice floating in the Harden valley lake of that time or by local extension of a tongue of ice up each of the valleys.

The ice-front to the east almost surrounded Old Allan Moor and invaded the col at Stream Head, being instrumental in forming the Stream Head lake and thus causing the breaching of the original watershed by an overflow channel at Bell Dean. A long winding but shallow overflow channel running past Allan Park Farm connected the Harden lake with that at Stream Head. Near its eastern end deposits of boulder-clay indicate that its course was partly determined by the ice-margin which swung in to Stream Head and then along the northern side of Harrop Edge.

Harrop Edge from over 1,000 ft. above O.D. at its western end rapidly falls away to the east, reaches 925 ft. at Shay House, and thence eastwards to Allerton does not again exceed that altitude. Boulder-clay stands up against Harrop Edge to a height of 900 to 925 ft. above O.D., consequently over-riding the whole of the Allerton ridge from Shay House to the east. The western edge of the position occupied by the ice as it crossed this divide is marked by a moraine in the form of a low ridge at Shay House, running north and south. A temporary excavation in this ridge proves it to be composed of a pell-mell arrangement of cobbles and boulders, averaging 9 in. to 1 ft. in diameter, mostly well rounded, some striated; a few pebbles and a little sandy gravel form the only matrix present. Several large blocks of grit occur in the neighbouring fields, a few attaining a diameter of 6 or 7 ft.

The north side of the Allerton ridge is thickly covered with boulder-clay, excavations for drains proving the unweathered blue clay at a depth of 9 ft. A minor overflow-channel having intakes at 870, 860 and 850 ft. above O.D. runs past " The Boggs " and enters the gorge of Chellow Dean on the Bradford basin side of the watershed as a hanging dry valley. Both this channel and the large one of Chellow Dean have at different times served to conduct the overflow of the Cottingley valley lake into the Bradford basin according to the level of the former and the position of the ice barrier. It has been shown that Chellow Dean has had at least two distinct periods of activity.[1]

The superficial deposits in the Bradford basin include two distinct types—the boulder-clay, and an overlying mass of waterworn gravel

[1] Jowett, A. and H. B. Muff, *op. cit.*, p. 232.

Digitized by Google

and sand which was deposited by the water escaping from the Harden and Stream Head lakes via the Bell Dean gorge when it entered the Bradford lake.

The boulder-clay covers the valley of the Pitty Beck as far as the southern end of Bell Dean and extends over the eastern shoulder of Thornton Heights Ridge, with an upper limit of 780 ft. above O.D. to Thornton Hall and Chat Hill. Thence the southern fringe of the boulder-clay swings eastward along Clayton Beck, gradually rising to 750 ft. at Clayton. A long low ridge follows the course of Clayton Beck from Chat Hill eastwards and is cut into at several points by that stream. Sections show a clay or clayey loam with many pebbles and cobbles and a few boulders, limestone and chert being not uncommon. Building operations near School Green have lately exposed as much as 12 ft. of stiff blue clay with boulders, the upper part tending to weather yellow. Other exposures in this area are poor, but indicate the presence of the boulder-clay.

The gravels overlying the boulder-clay in the Pitty Beck valley seem to have been deposited in the Bradford lake at two distinct periods, the level of the lake having, in the interval, fallen. Thus the dissected and partially eroded remnants of the earlier delta stand out as islands from the plane surface of the later deposit. This feature is further emphasised by the steep boundaries and flat tops of these isolated patches. The level of the Bradford lake during their formation must have been about 640 ft. above the sea. The lower and younger delta was being deposited when the lake level was about 600 ft., though probably the level was falling from this height to 560 ft. above O.D. during the deposition. Thus the high-level delta is surrounded by the later one at a level of 600 ft. at Broom Hill, while at Leventhorp Hall to the south-west the level is 560 ft. above O.D. The latter is practically complete and consists of a triangular spread of gravel with apex upstream and its surface a plane sloping down gently to the W.S.W., from 600 ft. at the apex to 525 ft. at Leventhorp Mills, a gradient of 1 in 60. This plane is dissected by the present course of the Pitty Beck, yielding several exposures. The best, however, is presented by a cutting on the new Thornton-Bradford road, just east of the bridge over the beck. The section seen consists of 25 to 30 ft. of current-bedded sand and gravel with many pebbles and cobbles but few boulders: fine silt and clay bands occur at intervals. The sand is generally coarse and sharp but contains many rolled fragments of shale. Grits and sandstones of the Millstone Grit and Lower Coal Measures are abundant, limestones frequent, while other sandstones and chert also occur. The materials of these gravels are obviously not restricted to those obtained from the cutting of Bell Dean, but include also a large quantity of drift probably brought over the col at Stream Head by the ice-margin.

Acknowledgments.—We are greatly indebted to the numerous firms working the coals, fireclays and building-stones of the district,

Digitized by Google

who have given us every assistance in our work. Special mention must be made of Robert Heath and Low Moor Ltd., the Leeds Fireclay Company, Joseph Morton and Company and Brook's Stone Company; our greatest obligation is to Messrs. Thomas Matthews, Ltd., Boring Engineers, of Pendleton, near Manchester, who have readily granted every facility for examining the cores from borings carried out by them. Among individuals we are indebted to Mr. A. G. Beaumont, engineer in charge of the Wakefield Corporation Waterworks extensions at Rishworth, to Dr. Woodhead, of Huddersfield, and Mr. C. Mosley, of the Tolson Memorial Museum in that town.

C. N. BROMEHEAD.

Digitized by Google

4. LANCASHIRE DISTRICT

Headquarters: Manchester

W. B. WRIGHT, M.I.M.E., District Geologist.
R. L. SHERLOCK, D.Sc., A.R.C.Sc., Senior Geologist
W. LLOYD, B.Sc.
L. H. TONKS, M.Sc.
R. C. B. JONES, M.C., M.Sc. } Geologists.

In Lancashire the western margin of Sheet 76, which presented considerable difficulties, has now been completed. In order to effect this, mapping had to be extended for about three miles westward into Sheet 75 (Preston), where no serious attempt at subdivision or correlation had hitherto been made. A satisfactory interpretation of this area has now been attained, mainly by the use of zonal correlations established in previous years in the better known region to the east. Mr. W. S. Bisat, upon whose work in Yorkshire this zoning is based, has now published his results, so that his nomenclature is available for purposes of description. A complete account of the application of this work to the Lancashire area known as the Rossendale Anticline will be given in the memoir on Sheet 76 to be prepared this year.

At the same time work has been started on the Middle Coal Measures in Sheet 85 (Manchester) to the south and on the Permian and Triassic beds which overlap their southern margin. Satisfactory correlation of coal seams has been attained over a limited area in the neighbourhood of Oldham, but has not yet been extended to other parts of the field.

MANCHESTER SHEET

Working in the area between Oldham and Ashton-under-Lyne, Mr. Lloyd has directed his attention chiefly towards establishing the Middle Coal Measures succession in this district.

A good deal of confusion in the nomenclature of coal seams has existed in the past; and though in most cases the correlation of important seams has been satisfactorily effected by the local mining authorities, it is at present impossible to tabulate a general detailed succession without involving considerable discrepancy with many of the individual shaft sections.

Much time has been spent necessarily in compiling the detailed records of numerous pit sections, and in this connexion it is desired to acknowledge the ready help accorded by the colliery officials throughout the district. Especial thanks are due to Mr. Hughes, manager of the Chamber Colliery Company, who, by the kind

Digitized by Google

permission of the managing director, Mr. Lees, has placed at our disposal the benefit of his experience and intimate knowledge of the Oldham coalfield.

A start has also been made on the mapping of the Lower Coal Measures and the Millstone Grits, which in turn rise from under the drift covered Middle Coal Measures to form fairly regular bare ridges on the east side of the area under consideration.

Mr. Tonks has been engaged upon the revision of the southern part of the city and suburbs of Manchester. A great many boring records have been obtained; and in this connexion we have received most generous help: Mr. J. B. L. Meek, M.Inst.C.E., the Manchester City Engineer, has supplied the journals of over two hundred boreholes, etc., together with some very valuable longitudinal sections showing the strata exposed during the construction of the sewers for the Main Drainage Scheme of the city. Professor George Hickling has lent the whole of his records of the boreholes with which he has dealt in his paper on "The Geology of Manchester."[1] Mr. J. W. Jackson, of the Manchester Museum, has lent notes of his own observations and those of the late Carl Roeder, of excavations in and about the city; and finally, a great deal of useful information has been obtained from notes and records kindly supplied by Professor Sir Wm. Boyd Dawkins and by Professor P. F. Kendall.

Millstone Grit Series.—The chief point of interest revealed by Mr. Lloyd during the preliminary survey of the higher members of the series is the change in character of the Rough Rock at Stalybridge.

In the original survey of the district,[2] Hull considered the Rough Rock to have disappeared entirely, and mapped the top of the Upper Haslingden Flags as the boundary of the Millstone Grits and the Coal Measures. The exposures on the west bank of the River Tame south of Glent quarry suggest, however, a modification of Hull's interpretation.

The following section is seen, commencing under St. George's Church, and continuing north-east to Tameside Mills:—

	Ft.
Flagstone (on which church stands) .. Woodhead Hill Rock	
Flags and mudstone .. .. about	20
Dark shale and mudstone .. .. about	50
Marine band with goniatites, pectens, etc., and bullions	
? Coal .. .. Small gap, obscured by slipping.	
Fireclay .. .. .. several feet.	
Raggy sandstone and sandy mudstone	6—8
Coal .. .. 1 ft. } partly obscured by slipping.	
Fireclay .. 3 ft. }	
Brown carbonaceous raggy sandstone	20

This section is of considerable importance as it has been dealt with by Stopes and Watson in the course of their study of coal ball

[1] *Trans. Inst. Min. Eng.*, vol. liv, part 5, 1918, pp. 367–417.
[2] 'Geology of the Country around Oldham' (*Mem. Geol. Surv.*), 1864, p. 15.

Digitized by Google

horizons.[1] They, however, do not record the sandstone between the two coal seams, nor that which underlies the lower. There can be no doubt as to their being *in situ* and representing the upper and lower leaves of the Rough Rock, the upper coal with the overlying marine band being the Six Inch Mine, and the lower the Sand Rock Mine.

The same horizon is exposed at Hough Hill, south of Stalybridge, and the authors cited lay stress upon the correlation of the two localities. At Hough Hill the upper coal and fireclay are unmistakably underlain by several feet of sandstone, but the possibility of this representing the upper leaf of the Rough Rock appears to have been overlooked.

A similar instance of the local weakening of the upper part of the Rough Rock has been observed near Bury,[2] while the lower portion is represented in the Naden valley, near Rochdale, by current-bedded fine sandstone.

Northwards from Stalybridge the Rough Rock regains its normal character as a massive coarse grit, forming the strong feature of Luzley Brows, near Mossley. At Mossley Cross the base is well exposed in the roadway, where its relation to the upper Haslingden Flags is clearly seen.

Lower Coal Measures.—In the area examined the outcrop of this series is confined to a narrow belt of high ground extending north from Stalybridge to Lees, having a uniformly steep dip to the west. The various subdivisions, as mapped in the Rochdale Sheet, have been recognised with few exceptions; and though these measures have not yet been proved by boring or sinking as at Burnley there is no reason for supposing any marked variation from the succession already published.[3]

The Woodhead Hill Rock forms a prominent feature easily traceable from Stalybridge to the outskirts of Oldham, and has been extensively quarried. On Brown Edge, Hartshead, it resembles Rough Rock in its coarser parts. The Lower Mountain Mine has been got fairly widely from the crop around Hartshead, but there have been no deep workings in this coal owing to its poorness as a commercial proposition, and the proximity of the rich Middle Coal Measures. The Bullion Mine Rock[4] has been recognised in the lane east of Hartshead Pike, which itself stands on Helpet Edge Rock, here coarse and massive. The Upper Mountain Mine had not been mapped in this district, nor has it been worked at all; it crops out, however, in the stream gully separating Boardman Edge and Hartshead Pike, and in the road between Hartshead Green and Broad Carr. The coal at the latter exposure was identified by Hull as Lower Mountain Mine, but its relation to the Helpet Edge Rock is now clearly visible. There is no evidence of the existence of the

[1] *Trans. Roy. Soc. London*, Series B, vol. 200, pp. 167–218.
[2] 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*), 1924, p. 62, sections.
[3] 'Summary of Progress' for 1922 (*Mem. Geol. Surv.*), 1923, p. 47.
[4] 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*), 1924, p. 67.

Digitized by Google

Cannel Coal which sometimes succeeds the Upper Mountain Mine.[1] The Milnrow (Crutchman) Sandstone is exposed at Hartshead Green as a rather coarse current-bedded micaceous flagstone, while the Old Lawrence Rock is characteristically represented by the fine brown rippled flagstones outcropping at Knott Hill reservoir and the Barracks quarry, Ashton-under-Lyne.

Middle Coal Measures.—The appended table of sections (Fig. 2) shows the correlation of the Middle Coal Measures in this district from the Royley or Arley Mine to the Sod Mine. The sections are linked together by intermediate evidence in such a manner as to place the general correlation beyond doubt. This succession constitutes the productive series. Above the Sod Mine (Fig. 2) about 650 yards of Middle Coal Measures have been proved at Ashton Moss Colliery, and some 400 yards in the deep boring at Lymeside, Failsworth, put down by the Chamber Colliery Co. No satisfactory correlation can be based on the records of these sections and considerable lateral variation can be presumed in the case of these higher measures. They are marked also by the absence of any notable beds of sandstone such as occur between the Black Mine and the Great Mine of Ashton-under-Lyne. The latter must not be confused with the Great Mine of Oldham which lies at a much lower horizon. Some of these sandstones are seen to persist throughout the area dealt with, e.g., the Blenfire (or Coney Green) Rock, the Rocher (or Chamber) Rock, the Foxholes (or Huncliffe) Rock, and the Bardsley Rock (Fig. 2). The sandstone underlying the Sod Mine at Dukinfield appears to die out in a northerly direction.

The coals which occur in the higher beds of Middle Coal Measures above mentioned, while fairly numerous, are not of any importance, few reaching a thickness of two feet.

Bands of *Carbonicola* have been recorded from several horizons, e.g., between the Major and Pottery Mines; 40 feet below the Major Mine; 15 and 30 feet below the Roger Mine; the floor of the Bottom Shuttles Mine; the roof of the Oxicrow Mine; the floor of the Higher Two Mines; and 66, 80, 111, 150, 184 and 187 yards above the Royley Mine. Two bands 15 feet apart have been discovered in the Lowside clay-pit near Oldham, between the Blenfire Mine and the Oldham Great Mine. In the Hollinwood district the *Carbonicola* bands lying below the Major and Roger Mines are regarded as being characteristic of these two seams; but here, as in the case of all the 'shell beds' of the Middle Coal Measures, lack of complete data and indifferent recording of the earlier sections renders doubtful at this stage any estimate of the value of the *Carbonicola* beds as zonal indices over a wider area. The marine band[2] lying some 200 yards above the Sod Mine consists of 2 feet of hard dark splintery limestone containing, amongst other forms, a goniatite at present unnamed. It is exposed in the River Tame near Dukinfield Station.

[1] 'Summary of Progress' for 1922 (*Mem. Geol. Surv.*), 1923, p. 53.
[2] 'Geology of the Country around Oldham' (*Mem. Geol. Surv.*), 1864, p. 32.

Digitized by Google

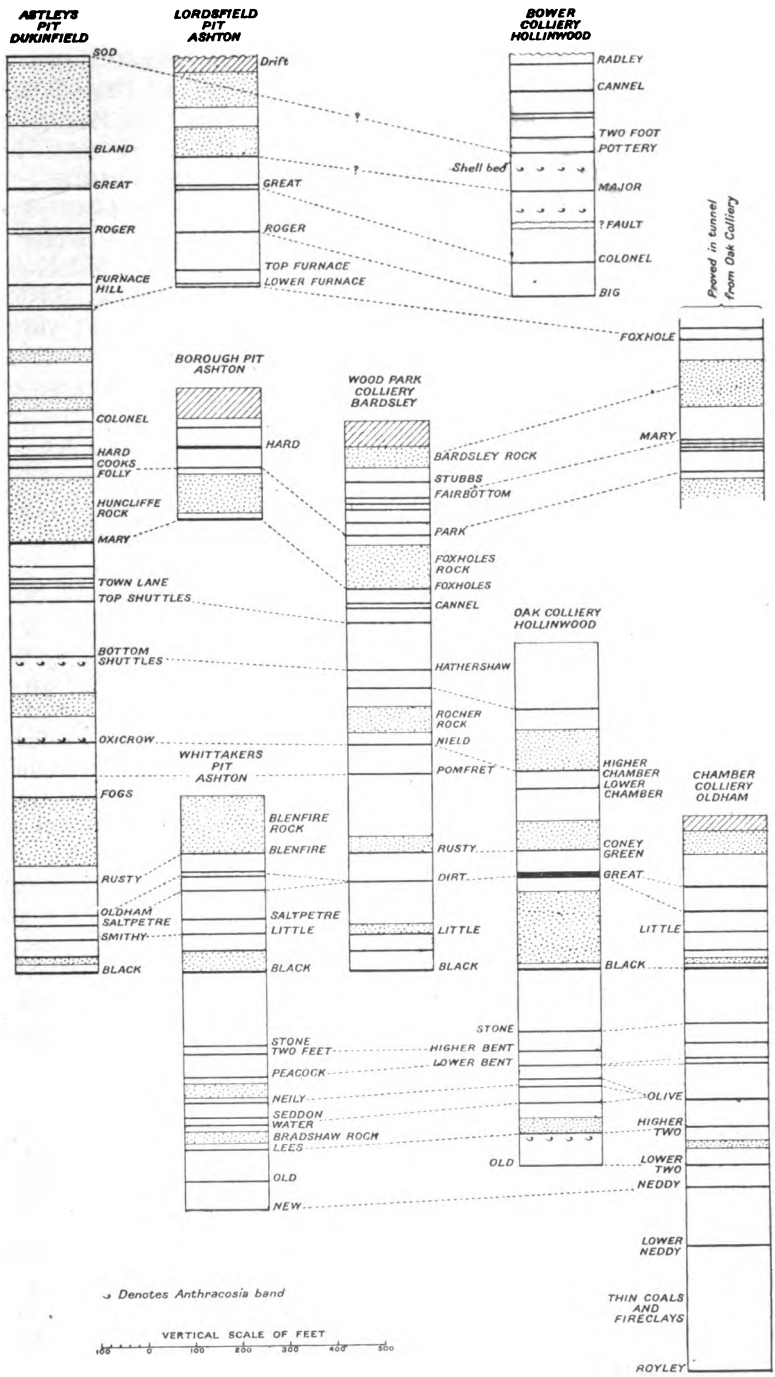

FIG. 2.—*Vertical Sections showing correlation of principal coal seams and sandstones of lower part of Middle Coal Measures between Oldham and Ashton-under-Lyne.* Reads South to North from left to right.

Digitized by Google

Upper Coal Measures.—The rocks which crop out in the area surveyed by Mr. Tonks are the Ardwick Limestone Series, the Collyhurst Sandstone, the ' Permian ' Marl, and the Bunter Sandstone. The Ardwick Limestone Series was limited by Hull to the southern side of the Bradford Coalfield ; but it has since been recognised further south in the Fallowfield railway cutting. The exposures in this cutting have been described in a series of papers in the memoirs of the Manchester Literary and Philosophical Society by Brocksbank and De Rance, and in the Transactions of the Manchester Geological and Mining Society by C. Roeder. Following this discovery, the presence of these beds close to the surface at various localities north-west of this cutting has been proved in several borings, etc. ; and, as no subsequent worker has failed to point out, this new information involves considerable alterations on the published geological map. Data are still very scanty, however, and while it is possible to draw boundary lines which conform closely to the information at present available, future exploration will doubtless make the detection of similar necessary alterations a possibility for years to come.

As Professor Hickling has shown,[1] the Ardwick Limestone Series is brought to the surface by the southerly continuation of the great Irwell Valley Fault, by which these beds are thrown up against Bunter Sandstone on the north-east. This major dislocation, as Hickling points out, has been proved at several places, and its approximate course can be traced across the city. Since Professor Hickling's paper was published, however, the fault has again been proved in the main sewer tunnel from Upper Moss Lane to Great Ancoats Street. The accompanying diagram (Fig. 3) illustrates the section proved and the exact position of the fault at this place :—

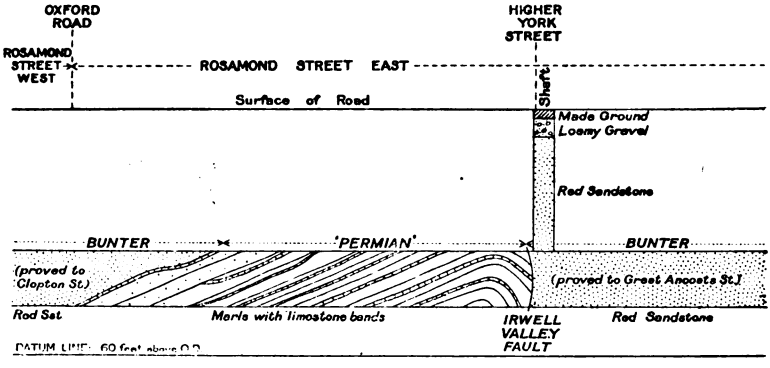

FIG. 3.—*Section of Irwell Valley Fault at a point 275 yards E.S.E. of All Saints' Church, Manchester.*

Horizontal Scale : 1 *inch* = 100 *feet.*
Vertical Scale : 1 *inch* = 50 *feet.*

[1] ' The Geology of Manchester as revealed by borings,' *Trans. Inst. Min. Eng.*, vol. liv, part 5, 1918, pp. 367–417.

Digitized by Google

Permian.—The Collyhurst Sandstone is not exposed in the area surveyed, but was proved at the surface in the High Street Baths borehole; in the sewer along Moseley Road; in the Fallowfield railway cutting; and in a sewer along Burnage Lane. The junction of this sandstone with the underlying Ardwick Limestone series was seen in the Fallowfield cutting and close by, in the Burnage Lane sewer, near Cringle Hall.

The 'Permian' Marls are known to occur at the surface in the yard of the Central Station, in Rosamond Street East (Fig. 3) and in Mauldeth Road, east of Broad Hill Farm; and the boundary between these marls and the underlying Collyhurst Sandstone has been proved at the junction of Burnage Lane and Mauldeth Road.

Bunter.—The Bunter Sandstone underlies the drift over the greater part of this area and may be seen in places along the banks of the Irwell, in the canal dockyards near Knott Mill, in the Fallowfield cutting, and immediately south of Alexandra Park Station. Its general dip is about 10 or 12 degrees to the west-south-west. The Bunter has been proved in many new localities in recent years, particularly by the excavations for the main drainage scheme of the city, and in many boreholes.

At the eastern end of Old Hall Lane, Withington, a hill of Bunter Sandstone rises from below the boulder clay, and here the rock is dug for sand for building purposes.

Glacial.—Boulder clay underlies most of south-eastern Manchester; but often there occurs above it, and occasionally separated from it by lenticles of sand and gravel, a stiff tenacious plastic clay with fewer stones. This upper clay is dug for brick-making in several pits. Patches of sand and gravel locally rest on the lower clays; and can be separated from those gravels which form a widespread terrace at Sale, Chorlton-cum-Hardy and West Didsbury, and run up the valleys of the Irwell and the Medlock. The nature and extent of this terrace of late glacial flood gravel has recently been described by Professor O. T. Jones.[1] It is cut into by the present flood plains of the Mersey and the Irwell.

Rochdale Sheet

Lower Coal Measures and Millstone Grit. — Mr. Wright completed the mapping of that portion of Sheet 76 between Darwen and Bolton. It is much broken up by a complicated system of faults and in places heavily drift covered. Mr. Jones's investigations further west beyond the limits of the Sheet assisted considerably in the interpretation of the evidence. Several key horizons were moreover found which gave clues to the succession in areas hitherto quite obscure. Thus the identification of the Pasture Mine at Orrell Moss, 2 miles north of Edgworth, gave a new interpretation

[1] In a paper shortly to be published in the Journal of the Manchester Geographical Society.

Digitized by Google

to a considerable area, and the coal formerly worked at Dimple, north of Egerton, having associated with it the last known mutation of *Reticuloceras reticulatum*, namely mut. γ Bisat, is thus indicated to be the Holcombe Brook Seam. The discovery of the two highest mutations of the same species, muts. β and γ, in the headwaters of Longworth Clough east of Belmont, has also afforded a clue to the succession in this very obscure area.

The Ousel Nest Grit has a powerful development in the south of this district, but wedges out with remarkable suddenness towards the north. The recognition of this fact has produced a profound modification of the mapping, and, combined with the rapid thickening of the Millstone Grits to the south-west, has necessitated a considerable amount of research outside the limits of Sheet 76 before a confident rendering could be given. It is hoped that sufficient precision has now been attained in most places to make the maps a serviceable guide in water boring. It cannot, however, be claimed that the fault system shown in the heavily drift-covered areas is anything but an approximation to the truth. The reality is probably much more complex.

On the moorlands westward from the margin of Sheet 76 Mr. Jones has been dealing with ground hitherto little explored and certainly to a large extent misinterpreted.

The recognition in several new localities of the marine bands containing *Reticuloceras reticulatum* muts. β and γ Bisat, which overlie the Helmshore Grit, has definitely proved the Anglezarke and Withnell Moors to be Middle or Third Grits and not Kinderscout Grit as formerly mapped.

Both the Fletcher Bank or Main Third Grit and the overlying Helmshore Grit maintain the same differences in lithology as shown in areas to the east.[1] A section of the former in Hatch Brook, which runs north-west from Withnell Moor to Brinscall, shows over 300 feet of coarse grit.

The shales between these two grits are very clearly exposed in the River Roddlesworth, north of Halliwell Fold Bridge. Here the fireclay and coal overlying the Fletcher Bank Grit and the fossiliferous horizon in the mudstones above may be examined in detail. This fossil band, which has been proved in several borings, is extremely thin and is found to yield only *Lingula, Orbiculoidea* and small fragments of fish remains.

The coal mentioned above has been worked to a small extent immediately east of Great Hill. In the Leicester Mill Quarries, near the south end of Anglezarke Reservoir, it is seen to rest on a remarkably uneven surface of the grit.

The marine bands above the Helmshore Grit show little variation from the section described at Higher Hempshaws,[2] except in the north of the area, where about 10 ft. of platy siliceous ironstone,

[1] Tonks, Laurance H. and W. B. Wright, 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*), 1924, Appendix II, p. 153.

[2] 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*), 1924, p. 63.

Digitized by Google

with an irregular ganister band and coal smuts, is developed between the Zone of *R. reticulatum* mut. β and that of mut. γ. These are exposed in stream sections in Tockholes Plantation. This would appear to be near the western limit of this ironstone and ganister development, so marked a feature of this horizon in the Irwell Valley north of Ramsbottom.

In the whole of the ground under consideration the general dip is southerly, and higher beds are brought on in this direction partly by this dip and partly by east-and-west faulting. West of Belmont this system of faults throws in the Brooksbottoms Series and Haslingden Flags. A second belt of faults, with the same general trend, is seen south of Smithills Moor, where the Lower Coal Measures are brought in to the south.

North of the village of Belmont the Brooksbottoms Series has been recognised on either side of the valley, so that the "Irwell Valley Fault" stated by the original survey to throw down 200 yds. to the east (*see* six-inch Sheet Lancs. 78) is here entirely absent or has only a negligible throw. The Fletcher Bank Grit is well exposed in the gorge east of Belmont village.

Some variation in the Brooksbottoms Series has been observed, particularly the absence of the upper leaf of the Brooksbottoms Sandstone and the development of a band of flaggy sandstone about 50 ft. below its base. This sandstone band appears to vary in thickness from 12 to about 30 ft., and is seen in Anshaw Clough, south of Bromiley, and above Ward's Reservoir near Belmont.

The Brooksbottoms Coal, which to the east is normally overlain by the upper leaf of the sandstone, is well exposed on High Brow and Grange Brow, south-west of Belmont, and is here seen to be overlain by about 20 ft. of mudstone. The Brooksbottoms sandstone is generally fine and rather siliceous, but coarse beds are met with.

The Holcombe Brook Series differs from the section at Holcombe Brook chiefly in the development of a sandstone directly below the Holcombe Brook Coal. This is only 6 feet thick where it is seen in Dean Brook, but to the north it increases to about 15 ft. of flaggy sandstone, which together with the Holcombe marine band above the coal is exposed in the stream running north from Siddow Fold. Below this sandstone is some 15 feet of sandy mudstone before the lower Holcombe Brook Coal is reached, which in turn rests upon a strong sandstone, the obvious equivalent of that forming the floor of Holcombe Brook.

The Lower and Upper Haslingden Flags show considerable variation in thickness and in the extent to which the flag bands are developed. North-west of Darwen Hill a considerable thickness of Lower Flags has been mapped, the strongest band being that on which the Haslingden Flag marine band rests. To the west, above Darwen, this has been extensively quarried, and in a quarry west of the Sunnyhurst Hotel the marine band and underlying flags are well exposed. These Lower Flags die out towards the south so that on the north face of Winter Hill they are completely absent, being

Digitized by Google

represented by 100 feet of mudstones, at the top of which, however, the marine band occurs.

In the north of the area there is a vertical distance of about 100 ft. between the Haslingden Flag marine band and the Rough Rock base. This is occupied chiefly by mudstone with two or three bands of very shaly flags. As these are followed south they increase considerably in thickness and reach a maximum of some 250 ft. on the eastern slopes of Counting Hill. Beneath this thick mass of flags and separated from them by about 80 ft. of mudstones is seen the Haslingden Flag marine band, but the Lower Flags are entirely absent.

The Rough Rock, below the Sand Rock Mine, is remarkably uniform in lithology and thickness, which is usually about 30 ft. It is a coarse felspathic grit with small quartz pebbles and has been found to cover an extensive area on Rivington Moor and to the north, in the neighbourhood of Tockholes. A thin bed of dark blue mudstone, with ironstone, is present beneath the Rough Rock wherever its base is exposed and appears to be very persistent.

Considerable variation has been observed in the Sand Rock Mine and overlying measures, the former being present as two seams over a considerable area. In the Horwich bore it has been proved to be one seam, while at Burnt Edge it has been worked as two seams, separated by 4 to 5 ft. of strata. This parting increases rapidly northwards to a maximum of 21 ft. on the moors south of Winter Hill. The lower coal varies from 8 or 9 in. to 1 ft. 8 in. with 18 in. to 3 ft. of fireclay below it, resting directly on the coarse grit. The measures between the coals vary considerably in lithology, and, where they are exposed in a stream south-west from Scotchman's Post, consist of sandy shale, which in other places passes into shaly sandstone. This is followed by 2 ft. of hard fireclay with a foot of good fireclay above, on which rests the upper coal. The coal is generally about a foot thick and has the characteristic plant remains in the roof.

Both coals and fireclays are worked for the manufacture of sanitary ware and stoneware pipes. A large area on the moors south of Winter Hill has been worked out.

The upper leaf of the Rough Rock is a current-bedded shaly sandstone, never exceeding a thickness of 35 ft. North of Rivington Pike it appears to die out entirely, while north of Darwen Hill it is seen to consist of about 3 ft. of shaly sandstone. A still higher sandstone band is developed locally, and is separated from the lower one by dark blue mudstone.

Much variation in the lowest beds of the Lower Coal Measures has been found to exist east of Horwich, particularly in the incoming of a considerable thickness of flags and mudstones and a grit, above the Six Inch Mine and below the Woodhead Hill horizons.[1]

---

[1] Tonks, Laurance H., and W. B. Wright, 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*), 1924, Appendix II, p. 155.

Digitized by Google

The Six Inch Mine which is taken elsewhere as the base of the Lower Coal Measures, is absent in this area, the marine band, however, which overlies this coal or is separated from it by a few feet of mudstone, is found to persist. Where not badly weathered it can be seen to consist of about 6 inches of hard calcareous mudstone, with numerous poor casts of goniatites and well preserved pectens.

A striking development of mudstones with two flag bands extends from the marine band up to the Ousel Nest Grit, a vertical distance of some 180 ft. This succession bears a close resemblance to that of the Haslingden Flags and Rough Rock, for which it could easily be mistaken but for the presence of the Six Inch Mine marine band below and of a coal below the Ousel Nest Grit. The similarity to one another of these two successions is very marked at the junction of the two streams in Shaw Wood, east of the southern boundary of the Lever Park, where the Six Inch Mine marine band and flags above it are faulted down against the Haslingden Flags.

The above coal is separated from the overlying Ousel Nest Grit by about 6 ft. of soft dark mudstone, the coal itself being from 6 to 8 in. thick. It is exposed, together with the flags below it, in New Field Clough, 500 yds. west of Walker Fold. The flags are also seen on Rivington Pike.

This coal is well known locally as the Margery Mine, a name given by the original survey[1] to a coal formerly worked along Fill Brook, south of White Coppice, where a ruined farm carries the name of Margery's Place. It is now clear, from the existence of the marine band with *Gastrioceras cancellatum* Bisat, a short distance above the Fill Brook Coal, that this latter is the Holcombe Brook Coal. Since the name Margery Mine is in such prevalent use at Horwich for this coal below the Ousel Nest Grit, and as there is no alternative name, it is proposed to let the name stand in this district, as the mine which occurs at what appears to be the type locality is now known to be the Holcombe Brook Coal.

The Ousel Nest Grit is coarse and current-bedded and has been extensively quarried along the high ground east of Horwich, where it is estimated to be about 120 ft. thick. At New Field Clough it is only some 30 ft. thick, while the dark blue mudstones which overlie it are much more prominent.

Lower Coal Measures have been mapped on Darwen Hill and farther north on Winter Hill and Bunker's Hill, and little variation is shown from the succession to the east. North from Winter Hill the Woodhead Hill Rock and the mudstones below it appear to thicken considerably.

W. B. WRIGHT.

[1] Six-inch Sheet, Lancs. 78.

Digitized by Google

5. CUMBERLAND DISTRICT

Headquarters: Whitehaven

BERNARD SMITH, M.A., Sc.D., District Geologist.
E. E. L. DIXON, A.R.C.Sc., B.Sc. } Senior
T. EASTWOOD, A.R.C.Sc. } Geologists.
F. M. TROTTER, M.Sc. } Geologists.
S. E. HOLLINGWORTH, B.A., B.Sc. }

WHITEHAVEN SHEET

The mapping of this Sheet (28) is now almost completed. Mr. Dixon has made great advances in interpreting the sequence in the Skiddaw Slates north of Ennerdale, and has mapped Carboniferous Limestone west of the fells. Mr. Eastwood has been engaged on the Coal Measures in the Clifton and Workington areas, and has now crossed the River Derwent into Sheet 22 (Maryport). Mr. Hollingworth examined a tract including higher Skiddaw Slates, Lower Borrowdale Volcanics and granophyre south of Ennerdale; whilst Dr. Smith mapped part of the Skiddaw Slates and Carboniferous Limestone near Cleator Moor and Egremont.

Examination of cores from borings, and collection of bore journals and mining records has been carried on as usual.

Skiddaw Slate.—In the area between Lower Ennerdale and Loweswater (Sheets 28 and 29) Mr. Dixon finds that the structure of the Skiddaw Slates is comparatively simple, and the following ascending sequence has been distinguished:—(*a*) Blake Fell Mudstones, (*b*) Kirk Stile Slates, (*c*) Loweswater Flags, (*d*) Mosser Striped Slates.

(*a*) The Blake Fell Mudstones are siliceous and argillaceous rocks at least several hundred feet in thickness; they have yielded no graptolites.

(*b*) The Kirk Stile Slates form a thin series of dark and striped slates with few graptolites. Their narrow outcrop has been traced from Loweswater village to Sharp Knott and probably continues south-west to Ennerdale valley. They occur also at Floutern Tarn.

(*c*) The Loweswater Flags are a thick series of alternating flaggy sandstones and grey and greenish slates. Graptolites are abundant at certain horizons. South of Loweswater the outcrop, which forms the western edge of the fells, is comparatively free from close folding, but to the north it is crossed by innumerable sharp folds and is greatly widened. Two rock-types new to the Skiddaw Slates have

Digitized by Google

been found. One is a grit or fine conglomerate containing many small black allochthonous phosphates[1]; the other is a black chert.

(*d*) The Mosser Striped Slates—narrow alternations of dark grey clay-slate and pale grey silty material—do not differ greatly from the Kirk Stile Slates. They occupy the narrow belt of ground between the fells and the country to the north-west, where they disappear beneath drift or Carboniferous Limestone. South-west of Mosser a number of graptolites[2] have been found by Mr. Templeman.

Miss Elles, who has examined the graptolites from the several groups, reports that "the various faunas all appear to belong mainly to the Zone of *D. extenus* [Arenig], though it is clear that some of the beds are lower in this zone than others. The presence of *Glyptogr. dentatus* together with *Didymogr. gibberulus* indicates beds fairly high up within the zone [Striped Slates at Whinnah, S.W. of Mosser], while the beds [Kirk Stile Slates] W. by N. of Smaithwaite, Lamplugh, should be very low in the zone (quite near the base), containing as they do large *Dichogr. octobrachiatus*; but for the rest [chiefly from the Loweswater Flags] the assemblages appear to be typical of the Zone of *D. extensus*."

The Skiddaw Grits of Clifton Ward, or Watch Hill Grits, have been traced to the west of their previously known outcrop until they meet that of the Carboniferous Limestone. By Ward these beds were regarded as part of the Skiddaw Slate Series, but owing to their anomalous composition and for other reasons they or their correlatives near Skiddaw have been suggested by Dr. Rastall[3] to be pre-Cambrian, and by Mr. J. F. N. Green[4] to be Bala. In composition[5] they have been found to bear so many resemblances to the grits in the Loweswater Flags that they probably belong to the Skiddaw Slates, a conclusion with which Mr. Green concurs.

South of the Ennerdale valley striped beds of very similar lithological characters to those just described have been mapped by Mr. Hollingworth beneath the Latterbarrow Sandstone. They are closely folded along axes pitching S.W. or W.S.W., but near their junction with the unfolded Latterbarrow Sandstones the dip usually follows that of the sandstone, and sandstone bands occur near the top of the slates.

Farther west similar beds have been mapped by Dr. Smith on the western slopes of Dent between Wath Bridge and Moss Dalts. At one point they yielded graptolites, determined by Dr. G. L. Elles as *Diplograptus* (*Glyptograptus*) cf. '*dentatus*' type. *G. dentatus* is found in the Upper Skiddaw Slates elsewhere (Ellergill Beds), its horizon being Upper Arenig or Llanvirn.

---

[1] Determined by Mr. R. Sutcliffe.

[2] First noticed by Prof. J. E. Marr and Mr. T. C. Nicholas.

[3] 'On the Skiddaw Granite and its Metamorphism,' *Quart. Journ. Geol. Soc.*, vol. lxvi, 1910, pp. 121–2.

[4] 'The Age of the Chief Intrusions of the Lake District,' *Proc. Geol. Assoc.*, vol. xxviii, 1917, pp. 19–26; 'The Skiddaw Granite,' *op. cit.*, vol. xxix, 1918, pp. 134–6.

[5] Mr. Dixon is indebted to Mr. Green for much help in making the comparison.

Digitized by Google

Associated with these beds is a series of dykes noted by Dr. Smith as occurring in two groups, a northern and a southern. Individually the dykes[1], though measuring up to 60 ft. in thickness, cannot be traced for more than a few yards. They appear or disappear abruptly—an effect apparently due to their being associated with the pitching minor folds in the slates. Collectively the dykes form a system of finger or rod-like branches rather than highly inclined sheets.

The Latterbarrow Sandstone, mapped by Mr. Hollingworth, forms a series of dominant hills, from the Cold Fell road to Lankrigg. Normally a greenish even-grained sandstone, it contains on Lankrigg much coarse grit with occasional pebbles of quartzite. The junction with the underlying Skiddaw Slates is not exposed, but a conformable relation is probable.[2]

Borrowdale Volcanic Series.—The Latterbarrow Sandstone passes up through ashy sandstones into a thick series of red and green mottled tuffs with sandstone fragments abundant in the lower part. These, the Mottled Tuffs of J. F. N. Green[3], form a well-developed and distinctive type at the base of the volcanic series from Boat How (Sheet 37) westward by Swarth Fell and Lowther Park to How Hills. They are succeeded by andesitic lavas showing a variety of compact, agate-bearing amygdaloidal, fluidal and flow-brecciated types. Augite andesites, probably intrusive, occur N.E. of the Wilton Fell limestone, and on Tongue How.

Carboniferous Limestone.—North of the great Mockerkin Tarn cross-fault, a certain amount of lateral variation in the Limestone Series was noticed by Mr. Dixon, though details are difficult to trace owing to faulting and the covering of drift; hence the lower limestones have not been recognised with certainty.

At the Broughton Crags quarries, near Papcastle, the Fourth Limestone is split up by thicker masses of clay-mudstone or shale than at Frizington and Rowrah. The Orebank Sandstone series has again become a mass of sandstone (which is indistinguishable lithologically from the Yoredale sandstones of the Yorkshire dales), and the Second Limestone and overlying shales are thicker. The First Limestone, in which the persistence of beds only a foot or so in thickness for distances of several miles is remarkable, has also been quarried; and the thin shales between it and the Hensingham Grit are well exposed.

Mr. Eastwood has studied good sections of the Hensingham Grit and First Limestone, which were at one time extensively quarried around Brigham. The grit is less coarse than at Hensingham and Distington. Blocks ploughed up in a field south of Brigham

[1] Smith, B., 'Summary of Progress' for 1921 (*Mem. Geol. Surv.*), 1922, p. 52; and S. E. Hollingworth, 'Summary of Progress' for 1922 (*Mem. Geol. Surv.*), 1923, p. 64.

[2] Green, J. F. N., 'The Age of the Chief Intrusions of the Lake District,' *Proc. Geol. Assoc.*, vol. xxviii, 1917, pp. 8–10.

[3] *Ibid.*, pp. 8–10.

Digitized by Google

Hill have yielded casts of brachiopods which have yet to be determined. The junction between grit and limestone is not exposed, but when free from drift, as at Brigham, the grit makes a prominent feature.

West of Brigham the ground is heavily drift-covered, and no sign of the Snebro Gill Beds and Millstone Grit Series has been detected. From a mile west of Brigham to beyond the coast line Productive Coal Measures are present.

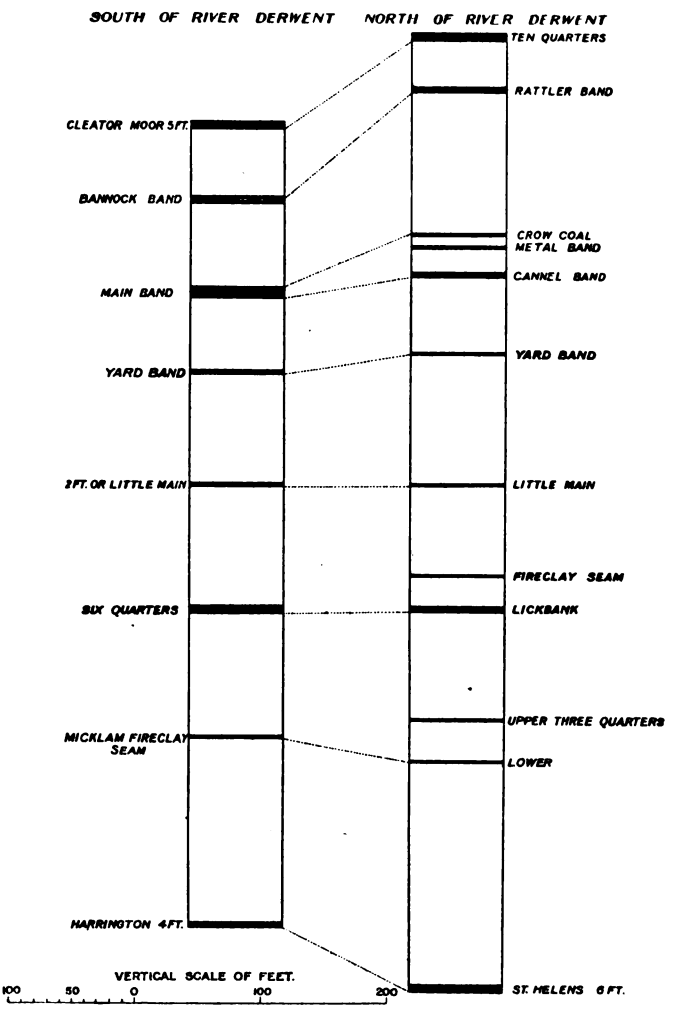

FIG. 4.—*Generalised Sections in part of the Cumberland Coalfield.*

Digitized by Google

In the area between Cleator Moor and Egremont Dr. Smith has mapped a tract of Carboniferous Limestone, including the Seventh to the Fourth Limestones, that has been extensively mined for haematite. A new point of interest is the occurrence of the Fifth Shale, with abundant *Chonetes*, at intervals.

Coal Measures.—Mr. Eastwood finds that important changes between the coals of the Whitehaven and Maryport fields take place in the Coal Measures neighbouring the valley of the Derwent.

Owing to changes both in coals and intervening measures, correlation of individual seams in the two main areas is impossible in certain cases; whilst a further complication has been introduced by the haphazard naming of seams that bear a superficial resemblance to one another. The measures below the Main Band have altered less than those above, although some new workable seams make their appearance (Fig. 4); the Harrington Four Foot—a mere streak around Whitehaven, though a workable seam of rather poor quality at Harrington, Oatlands and Wythemoor Collieries—is known as the Six Foot at St. Helens. Eastward, along the Derwent valley, it appears to degenerate, and at Camerton is represented by two thin seams.

Coals between the Harrington Four Foot and the Six Quarters are thin and poor as a rule south of the Derwent, although one—the Micklam Fireclay Seam—is mined with fireclay at the Harrington Colliery. In the northern area two seams are worked; the lower, generally known as the Lower Three Quarters (or 'Mystery Seam' of Camerton), occurs near the middle of this belt of strata and appears to be equivalent to the Micklam Fireclay Seam; whilst the upper, known as the Three Quarters, Upper Three Quarters or Low Main, occurs 30 or 40 ft. higher in the sequence.

The Lickbank of the northern area is generally accepted as equivalent to the Six Quarters of Whitehaven, which may be further correlated, in the intervening ground, with the 'Yard' of Distington.

The Little Main, or Two Foot, persists throughout the greater part of both areas and averages 2 ft. of good coal.

In the southern area no seams between the Six Quarters and Little Main are of workable thickness; but north of the Derwent, one, about 2 ft. thick, has been worked around Camerton as the 'Fireclay Seam.' Coals in this belt of strata thicken northwards in the undersea portion of the Harrington Colliery, and are known as the 'Lickbank' and Potash seams.

The Yard Band ranges throughout. Probably its quality is better in the northern district, since it has been there more extensively wrought than in the southern area.

The Main Band—the chief seam in the Whitehaven district—is characterised by a band of inferior cannel[1] in its lower part whilst thin dirt bands are of exceptional occurrence. Near Clifton the

[1] 'Special Reports on the Mineral Resources of Great Britain,' vol. vii, Cannel Coals, &c. (*Mem. Geol. Surv.*), Ed. 2, 1920, pp. 73–74.

Digitized by Google

Derwent valley overlies an area in which the Main Band is cut out by its sandstone roof. North of this the seam splits, the lower part being known as the Cannel Band, the upper part as the Metal Band. Over Broughton Moor and towards Flimby the two seams are as much as 30 ft. apart. Further splitting of the Metal Band gives rise to the Crow Band.

Greater changes occur above the Main Band. The Bannock Band of the southern district is scarcely recognisable in the north, although the Rattler Band may possibly represent its upper portion. On the other hand, coals of, and above, the horizon of the Cleator Moor seams become more prominent; they are thicker, of better quality, and have been worked considerably. Most valuable is the Ten Quarters, worked at most of the collieries as a seam averaging from 5 to 6 ft. of coal. It occurs in the same position as the China, Spar or Cleator Moor Five Foot, with which it is correlated, and has a similar roof of light blue sandy mudstone. To this correlation we may add the Moorbanks of Workington, which occupies a similar position, about 200 ft. above the Main Band. In this respect we find ourselves in agreement with Mr. J. D. Kendall.[1] Russell,[2] on the contrary, considered that the Ten Quarters and the Moorbanks represented the Cleator Moor Four Foot, the Rattler Band being equivalent to the Cleator Moor Five Foot.

In the overlying 200 ft. of strata coals two or three feet in workable thickness are fairly evenly distributed. Terminology has been confused, but the following names, in ascending order, are in general use :—Slaty, Upper Yard or Little Coal, White Metal, Black Metal and Brassy Bands. All of these have been worked in the northern area, either alone or in conjunction with fireclay.

Glacial.—Dr. Smith notes that Scottish erratics occur commonly to the west of Cleator Moor and the River Ehen at Egremont, but more rarely for some distance to the east of this line. The boulder-clay upon the western slopes of Dent (Skiddaw Slates) contains a fair percentage of red and sandy material, and of erratics from the Coal Measures and New Red outcrops to the north. The largest and most common boulders, however, are of granophyre, Skiddaw Slates (many metamorphosed) and volcanics. A bar of sand and gravel thrown across the mouth of Ulldale near Moss Dalts by ice retreating westward, diverted, in conjunction with the ice itself, the overflow from glacier-lake Ennerdale into the valley of the stream that passes Hale and Beckermet (Sheet 37). Near the Ehen at Egremont there are masses of sand and gravel that are possibly connected with a well marked drainage channel south-east of Row Farm.

In the upper part of the Calder drainage, studied by Mr. Hollingworth, local boulder-clay occupies much of the lower ground. The abundance of boulders derived from the Ennerdale valley in the

[1] 'The Structure of the Cumberland Coalfield,' *Trans. Inst. Min. Eng.*, vol. xxxii, 1883, p. 341.

[2] *See* Vertical Sections, Sheet 75, *Geol. Surv. of Eng. & Wales.*

Digitized by Google

area between Dent and Cold Fell indicates a strong flow of Ennerdale ice south-west over the Black Pots col east of Crag Fell. Erratics prove that western ice reached as far as Wilton in the area S.E. of Dent. Here a number of marginal and direct overflows drain south and south-east between Wilton and the River Calder; with these are associated small patches of gravel.

Brampton Sheet

Work in this Sheet (18) has been advanced by Messrs. Trotter and Hollingworth, the former on an east-and-west line between Linstock and Haltonlea Gate, the latter from the neighbourhood of the Gelt valley near Castle Carrock west to the Eden. Study of the Coal Measures of Midgeholme and the coals of the Limestone Series has added considerably to our knowledge of the sequence. The eastern limits of the Upper Boulder Clay of the Carlisle plain have been determined, and isolated glacial phenomena linked together.

Carboniferous Limestone Series.—In the Brampton and Midgeholme districts Mr. Trotter finds that the sequence of the Middle Limestone Group, determined by him in 1923,[1] holds good over a wide area. That of the Upper Group and the greater part of the Lower Group has now been established.

The lowest beds of the district occur below the Tyne Bottom Limestone and are exposed almost continuously in Castle Beck, which flows past Naworth Castle. The sequence, which appears to be unfaulted, although palæontological evidence is wanted to establish this point, consists of approximately 1,400 ft. of thin limestones, sandstones and shales, all more or less stained red. The limestones are fossiliferous and account for no more than 100 ft. of the strata.

Limestones from the Scar to the Great have been mapped on Tarnmonath Fell and Simmerson Hill east of Castle Carrock. The Great Limestone has been quarried for road-metal and lime.

The Little Limestone Coal is from 5 to 6 ft. thick, but it splits locally into two or three coals. In these cases the Main Coal only, which averages 3 ft., is worked, and it may be immediately below the limestone, or as much as 40 ft. below.

In recent times the Main Coal—from 3 ft. to 3 ft. 7 in. thick—has been worked beneath Tarnmonath Fell from its outcrop at Gairs eastward to a north-and-south dislocation. The coal is bright and soft and shows cone-in-cone structure, but varies in quality in different parts of the mine owing to the intrusion of a whinstone which has driven off some of the volatile constituents. It is expected that considerable reserves lie to the east of the fault, but their value depends upon the effect of the overlying whin, which occurs from 200 to 250 ft. above the coal in the pit.

[1] 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*), 1924, pp. 71–73.

Digitized by Google

A large E.N.E. fault, down north, throws the outcrop to the west side of Simmerson Hill, where the coal was formerly worked from Blacksike Colliery. The workings are bounded on the north by a fault which shifts the outcrop more than a mile east to Howgill, in which neighbourhood coal has been wrought for at least 100 years.

South of Tindale Tarn the coal has been worked extensively from its outcrop between Howgill and a N.W. fault 500 yds. E. of Henry Pit (Bishop Hill). The exploitation of the seam between this fault and the Spelter Works (near Doles Hole) appears to have been checked by a wash-out in the coal near its outcrop.

On Denton Fell the coal has been worked only a short distance from outcrop. Near Whamoss Rigg a thickness of 3 ft. 6 in. is exposed. Since a boring 1 mile east of the outcrop proved a 3 ft. 7 in. coal beneath the Little Limestone, at 820 ft. depth, it is concluded that a large area of untouched coal may underlie the fell. Two coals 2 ft. 3in. and 1 ft. thick, claimed to be those beneath the Little Limestone, were proved in an old trial shaft ½ mile east of Haltonlea Gate at depths of 144 and 170 ft. As the thickness and character of the strata on Byers Fell are confirmatory, it is probable that unworked coal underlies the fell at accessible depth.

Above the Firestone Sill the beds consist of sandstone (in places calcareous), shale, minor bands of limestone and thin coals. The sequence is difficult to piece together from the isolated outcrops, but two borings near Midgeholme have provided a record of 1,428 ft. of rocks, from the Low Main Coal (Coal Measures) to the Little Limestone, in which the top of the Upper Fell Top Limestone occurs 1,046 ft. above the base of the Little Limestone. In this series the Oakwood Coal, 1 ft. 7 in. thick, is recorded in the Denton Fell boring, 340 ft. above the Little Limestone, and a 2 ft. coal occurs at the same horizon in a boring at Wallnook, east of Simmerson Hill. This coal crops out in Howgill Beck.

Farther south Mr. Hollingworth discovered that the group of coarse pebbly conglomerates, greenish grits and red shales mapped by him in the Cumrew area last year, extends northward as far as Albyfield, where they are cut out by the overlap of the Trias. Where best developed, south-east of Albyfield, they are several hundred feet in thickness, and the overlying succession closely resembles that above the basement beds of the Roman Fell district.[1] A sandy crinoidal limestone, with occasional pebbles of quartzite, is succeeded by poorly exposed shales and sandstones, and these by a big limestone scarp lithologically resembling the Melmerby Scar Limestone but hitherto regarded as representing the higher Yoredale limestones. The identification, however, of fossils of the Lower Dibunophyllum Subzone confirms its equivalence to the Melmerby Scar Limestone. The pebbly limestone may represent Westmorland Pennine equivalents of the Brownber Pebble Bed.[2]

[1] Garwood, Prof. E. J., 'On the Lower Carboniferous Succession in the North-West of England,' *Quart. Journ. Geol. Soc.*, vol. lxviii, 1912, p. 537.

[2] *Ibid.*, p. 537.

Digitized by Google

In the River Gelt, east of High Gelt Bridge, there is an almost continuous section of 1,000 ft. of limestones, shales and sandstones with occasional thin coals. The lower half includes thick limestones of the Upper Dibunophyllum Subzone, the probable equivalents of those immediately above the Melmerby Scar Limestone farther south. These beds are separated from higher Yoredales lying to the east—the Scar to the Little Limestone—by a fault trending from Havannah down Mill Beck.

The Four Fathom Limestone, with cherts, has been quarried extensively ¾ mile E. of Castle Carrock, where it is thrown into a series of acute folds of small amplitude.

The Little Limestone Coal has been worked out under Talkin Fell.

The Hynam Coal, locally 2 ft. 3 in. in thickness, has been sparsely worked below the ? Five Yard Limestone near High Hynam.

Millstone Grit.—The precise thickness of strata, between the Upper Fell Top Limestone and the lowest seam in the Coal Measures, that should be allotted to the Millstone Grit has not yet been settled.

Coal Measures.—The Coal Measures of Midgeholme occupy a syncline, the southern limb of which is faulted by a downthrow north —the Stublick Fault— of approximately 1,500 ft. Westward the throw decreases, and south of Blacksike Colliery it is about 600 ft.

Six coal seams occur in the 500 ft. of measures above the base of the Low Main Coal.

The Low Main Coal (or Little Midgeholme) is from 2 ft. 2 in. to 2 ft. 6 in. in thickness near Haltonlea Gate. Westward it appears to split, and the overlying 20 ft. of measures, up to the Slag Coal, thicken to 40 ft. The coal crops out N.W. of Midgeholme in Haining Burn, where it is 13 in. thick.

The Slag Seam (Great Midgeholme, Five Quarter or Seven Quarter) averages 5 ft. in thickness and is of good quality. It has been burnt by a doleritic sill in Whitescut Colliery. The sill occurs at the western end of the coalfield, usually between the Low Main and Slag seams.

The Cannel Coal, 20 to 30 ft. above the Slag Seam, consists of two coals, 8 in. to 18 in. apart ; the upper is from 14 to 18 in. thick, the lower consists of 18 in. of good cannel which has not been exploited.

The Wellsike Seam lies 70 to 90 ft. above the Slag Seam. It is a good household and steam coal, averaging 4 ft. 6 in. in thickness.

The Three Quarters occurs about 60 ft. higher. It consists of from 2 ft. 2 in. to 2 ft. 8 in. of household and steam coal, and is now being raised at Lambley.

The Craignook (Seven Quarters) comprises two seams separated by 2 to 7 ft. of fireclay, and lies 60 to 100 ft. above the Three Quarters. The Lower Craignook is being wrought for house and steam coal at Lambley Colliery, whence the section is as follows :—

Digitized by Google

		Ft.	in.
Upper Craignook	Coal	0	6
	Seggar	0	4
	Coal	3	9
	Black Seggar	0	4
	Coal	0	8
	Fireclay	6	6
Lower Craignook (Yard or Five Quarters)	Coal	2	9
	Coarse Cannel	0	10
	Cannel	0	5
		16	1

Above the Upper Coal is about 70 ft. of ' Craignook Sandstone.' With the exception of the Low Main and the Cannel Coal the principal seams have all been wrought extensively, the Slag and Wellsike being practically exhausted.

New Red Series.—In the neighbourhood of Castle Carrock Mr. Hollingworth finds that the Trias rests unconformably upon the Carboniferous, and that there is no evidence for the northward prolongation of the Pennine Fault into this area; there is some evidence, however, that movement took place along the Stublick Fault in post-Triassic times.

In the River Gelt St. Bees Shales, with a bed of pebbly red sandstone and breccia at their base, rest on variegated Carboniferous shales and purplish sandstones.

St. Bees Sandstone occupies most of the ground between the Eden and the Pennine escarpments. It is well exposed in quarries and along the gorge of the Eden.

Glacial.—Much of the ground in the Gelt valley east of Castle Carrock is occupied by boulder-clay containing a small percentage of erratics from the west, mixed with local Carboniferous material.

The deltaic deposits of the Brampton district studied by Mr. Trotter[1] and described by him in last year's Summary of Progress, and which represent the retreat phenomena following the maximum glaciation, have now been linked up by Mr. Hollingworth with similar deposits showing the stages of ice retreat in the Cumrew area.

When traced westward in both areas the sands and gravels are found to pass beneath an Upper Boulder Clay—thus giving rise to a tripartite division of the drifts. In the Brampton district Mr. Trotter has recognised definite deltaic forms beneath the thin eastern fringe of Upper Clay; whilst Mr. Hollingworth has noted eskers, extending westward from the 375-ft. deltas, which retain their ridge form unimpaired beneath their partial covering. Farther west the features of the Middle Sands are blotted out by the Upper Boulder Clay, and the sands can then be mapped separately only when exposed in the flanks of hill or valley. In the Cumrew area

[1] ' Summary of Progress ' for 1923 (*Mem. Geol. Surv.*), 1924, pp. 77–79.

Digitized by Google

the three groups of drift contain both Lake District and Scottish erratics.

Mr. Trotter has now mapped Middle Sands and Upper Boulder Clay as far west as Linstock, on the same longitude as the similar deposits on the south side of the Eden at Carlisle, thus linking up the two areas. The re-advance of the Scottish ice, judged by the extension of Upper Clay over the Middle Sands, can now be said definitely to have been at least 12 miles. This re-advance may be correlated tentatively with the re-advance of the Scottish ice in N. Ireland,[1] of the Irish Sea ice at St. Bees[2] and of the Howgill Fell ice down the Vale of Eden.[3]

In its final retreat the ice gave rise to the glacial lakes of the Carlisle Plain.[4] Mr. Trotter has detected a delta discharged into the 100 ft. lake from the Eden valley.

BERNARD SMITH.

[1] Charlesworth, J. K., 'The Glacial Geology of North West Ireland,' *Proc. Roy. Irish Acad.*, vol. xxxvi, Sect. B., No. 12, 1924, p. 294.

[2] Smith, B., 'Summary of Progress' for 1921 (*Mem. Geol. Surv.*), 1922, pp. 67-68.

[3] Kendall, P. F., 'Geology of the Vale of Eden,' *Naturalist*, 1912, p. 110.

[4] 'Summary of Progress' for 1922 (*Mem. Geol. Surv.*), 1923, pp. 61–63.

Digitized by Google

6. NORTHUMBERLAND AND DURHAM DISTRICT

Headquarters : Newcastle-on-Tyne

R. G. CARRUTHERS, District Geologist.
G. A. BURNETT, B.Sc.
J. MADEN, M.Sc.
A. FOWLER, M.A., B.Sc.
W. ANDERSON, M.Sc.
} Geologists.

The field work of the Northumberland and Durham unit has, during the past season, been carried out for the most part in country east and south-east of the Cheviot massif, though small areas in the vicinity of Newcastle have also been revised. As regards the distribution of the work, Mr. Carruthers was engaged in the Alnwick district, Mr. Burnett on the Cheviot lavas round Ilderton and west of Wooler, while Mr. Anderson revised areas of Fell Sandstone and Cementstones around Edlingham. To the south and east, Mr. Fowler finished a small area near Rothbury, and then moved on to the Coal Measures south of Warkworth ; Mr. Maden continued this work to the south, and earlier in the year was also engaged on these rocks in the suburbs of Newcastle, Mr. Anderson taking the ground south of the Tyne, in Co. Durham.

In so far as the Cheviot Lavas are concerned, it would be premature to make any general statements, for the revision is only in its initial stages, and undoubtedly presents difficulties. The chief feature of general interest in the year's work is the reading of the Upper Limestone sequence in Mr. Fowler's ground along the River Coquet and its tributaries. These sections provide an invaluable link between the succession established in the Tyne valley, and that found on the Howick coast—the most northerly exposure of such rocks in Northumberland. Without such a link, correlation would have been mere guess-work, for the areas are fully 30 miles apart. Mr. Fowler's field-work along the Coquet was done in 1922, but the full utilisation of his data depended on the examination of adjacent areas, now completed.

Cheviot Lavas.—Mr. Burnett's work near Wooler deals with the north-eastern fringe of the Cheviot massif. As is well known, this igneous complex, of Lower Old Red Sandstone age, is built up of andesitic lava flows, traversed by occasional porphyrite dykes, and with a central core of granite. The monotonous similarity of the lavas, and the extensive weathering and alteration they have undergone, hinder revision work considerably. The main disposition of the rocks is clear enough, but no secure basis has yet been found for mapping individual flows. There are colour differences—the shades vary from purple to dark grey, in some cases almost black—but so

Digitized by Google

far these do not seem to coincide with any change of petrographical type. Neither are vesicular flow junctions by any means obvious: one of the few cases yet observed, in the Lilburn Burn, west of Ilderton, requires close examination before it can be detected: while on the other hand, an apparent junction, very clearly exposed in a steep bank above the stream near Old Middleton, proved to be only a horizontal crush-line in the heart of a flow.

In the upper part of Lilburn Burn, about South Middleton Moor, thin veins and sills of granite appear among the andesites, and rapidly become more numerous and important as the northern margin of the main granite boss is approached.

Cementstone Series.—Near Humbleton the lowest Carboniferous sediments are marls or marly sandstones, with fragments of Cheviot igneous rocks: no trace of the Roddam Dene conglomerate was noticed. Ten miles to the south-east, Mr. Anderson, working in the Callaly-Edlingham district, finds that both the Cementstones and the Fell Sandstones are constantly repeated by large faults, the two groups therefore being spread over a considerable stretch of country: the chief dislocation, with a throw of 1,500 ft. to the west, runs from Rough Castles north by east to Woodhall, near Bolton. Good field sections are not common, the best being in the road cutting 1 mile east of Bridge of Aln Inn, where some 200 ft. of the Cementstone Series is exposed. In this section there are the usual alternations of green and purple marly shales, with bands of grey cementstone and sandstone: the most interesting point is the confirmation by Mr. Anderson of Tate's original discovery here of *Rhynchonella* fragments:[1] they are found in a tough calcareous band a few inches thick, lying about 50 ft. above the lowest rock exposed.

Westwards the cementstone bands appear to thicken out and have been quarried extensively at Whittingham Wood, High House and Kiln House. This is in agreement with the abnormally thick development previously noticed in the Coquet valley,[2] in which region Mr. Fowler has now completed his revision. There is reason to suppose that the Glebe and Tosson limestones wrought hereabouts are one and the same bed, the occurrence of large concretionary structures being one of the features they possess in common: these concretions had previously been noticed by Mr. Clough in the Whitfield Burn section.[3] A noteworthy point observed by Mr. Fowler is the presence of small crinoid ossicles in one of the highest limestones of the series, near Cockpit Well, south of Great Tosson: this seems to be the first record of such purely marine fossils in the Cementstones of Northumberland. Associated with them are *Murchisonia*-like gasteropods, while at a lower horizon, a *Rhynchonellid* fragment was got from the thick limestone in the Black Burn, east of Newtown.

---

[1] Tate, G., 'The History . . . . of Alnwick,' 1866–69, p. 445.
[2] 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*), 1924, p. 81.
[3] 'Geology of . . Otterburn and Elsdon' (*Mem. Geol. Surv.*), 1887, p. 14.

Digitized by Google

Fell Sandstone.—Step-faulting is responsible for the large area covered by this group in Mr. Anderson's ground. There are prominent crags between Callaly and Lorbottle, the sandstones being in three tiers, parted by sandy shale: the average thickness of the whole series is about 800 ft. The sandstones are of the usual friable, coarse and false-bedded type, and call for no special remark. They seem to be thicker towards the south, and in the Simonside Fells may amount to 900 or 1,000 ft., but accurate estimates are impossible, owing to false-bedding. Mr. Fowler has traced a fault of considerable size under the north face of the Simonside escarpment; the displacement varies from place to place, a feature probably due to extensive lateral movement.[1]

Scremerston Coal Group.—In the Coquet valley and south thereof, the recent recognition of this group is of considerable stratigraphical interest, although unfortunately the coals are far too thin and dirty to be of economic importance. Last year Mr. Fowler reported the discovery of *Sanguinolites* and *Euphemus*-like organisms in these measures north of Rothbury, in the Debdon Burn, and at a new locality, where this stream is crossed by the Debdon-Rothbury road, he has now obtained further evidence of marine, or semi-marine conditions: amongst the fossils collected Dr. Lee has identified *Lingula squamiformis* Phill., *L. mytiloides* J. Sow., and *Edmondia pentonensis* Hind.

In the moorland 3 miles south of Rothbury, Mr. Maden has discovered good sections of the Scremerston Series in the stream below Blagdonburn farmstead. Nearly 500 ft. of strata are seen, although the section is far from continuous: most of the beds are fine-grained sandstones and shales, but amongst them are ochreous cement limestones of Scremerston type, along with several thin coals (none over 1 ft. thick) and a 30-in. ganister. Farther upstream, about ½ m. east of Selby's Cove, numerous blocks of pale grey cement again suggest that Scremerston measures are present.

The Lower Limestone Group.—Mr. Maden has noted two exposures of the Dun Limestone, one in the Chertner Burn, the other in the Newbiggin Burn, ½ m. or more above the junction of these streams: in the first-named, faulting repeats the limestone twice in a distance of 200 yds. The stone is from 10 to 15 ft. thick, grey and crinoidal, with a marked ochreous weathering: it is well bedded throughout. Compound corals (*Lithostrotion* &c.) and *Producti* abound in the upper layers.

No exposure of the Woodend Limestone has yet been found in the Rothbury district: the nearest section is in the Hobberlaw quarries, south of Alnwick, where 5 ft. of limestone can still be seen, the full thickness being 10 or 12 ft.: this is covered by 10 ft. of fireclay and marly shales, on which is a 12 in. coal. The limestone

[1] Compare the similar case recorded in the 'Summary of Progress' for 1923 (*Mem. Geol. Surv.*), 1924, p. 84.

Digitized by Google

here is white or very pale grey, and has a pronounced pseudo-brecciated structure, features highly characteristic of this horizon in more northern areas.

The Upper Limestone Group:—Work on the Upper Limestone sequence is now sufficiently advanced to justify a correlation of the Howick coast section (the northern limit of these rocks) with the Tyne valley sequence, 30 miles or more to the south-west: the link between them is supplied in Mr. Fowler's ground, along the lower reaches of the Coquet, where the revision has led to several alterations and additions to the original mapping: this is supplemented by a deep boring at Broomhill, to the east. The Howick coast section, surveyed by Mr. Carruthers in 1922–3, provides a practically continuous sequence from the Millstone Grit down to the Great Limestone (Fig. 5). With the exception of the Sugar Sands Limestone (10½ ft.) all the limestones are very thin. Amongst the intervening strata the most noteworthy feature is the 60-ft. shale separating the two Foxton limestones. The Lickar Limestone is remarkable for the richness and variety of its fauna, and the Sugar Sands and Iron Scars Limestones for the abundance of *Productus latissimus*, but the other limestones have no special palæontological feature.

The Coquet section (Fig. 5) is clearly in strata above the Lickar Horizon, for both limestones contain *Productus latissimus*, and as no thick shale of the Foxton type is present, one may provisionally correlate the chief limestone, that of Felton St. Mary's, 6 ft. thick, with the Sugar Sands position. Three miles to the north-east, in the upper beds of the Mere Burn section, there is a 60-ft. shale, unlike anything in the Coquet sequence, but strongly reminiscent of the Foxton shale, not only in itself, but in the occurrence of two thin limestone bands, one at the base (the Brainshaugh Limestone) 3 ft. thick, and one towards the top. In confirmation of the suggested correlation with the Foxton beds, one naturally looks for some representative of the thick Sugar Sands-Felton St. Mary's Limestone below. As a matter of fact, a limestone is actually seen in the Mere Burn, about 200 ft. below the Brainshaugh position. The exposure is at first sight disappointing, for no more than 3½ ft. can be seen; but Mr. Fowler noted that where this bed crosses the stream, more water flows into the pool than out of it: a valuable observation, for it indicates beyond doubt that we are looking at the upper part of a thick bed of limestone, in which some of the water has escaped underground: there need be little hesitation in correlating it with the Sugar Sands position.

The Coquet and Mere Burn sections can therefore be identified without difficulty with the Howick sequence: they show, moreover, that an unconformity previously noted in the Howick–Foxton district, which in places cuts out the Foxton Limestone,[1] is of merely local importance.

Turning now to the Tyne valley succession, the sequence as a

[1] 'Summary of Progress' for 1922 (*Mem. Geol. Surv.*), 1923, p. 73.

Digitized by Google

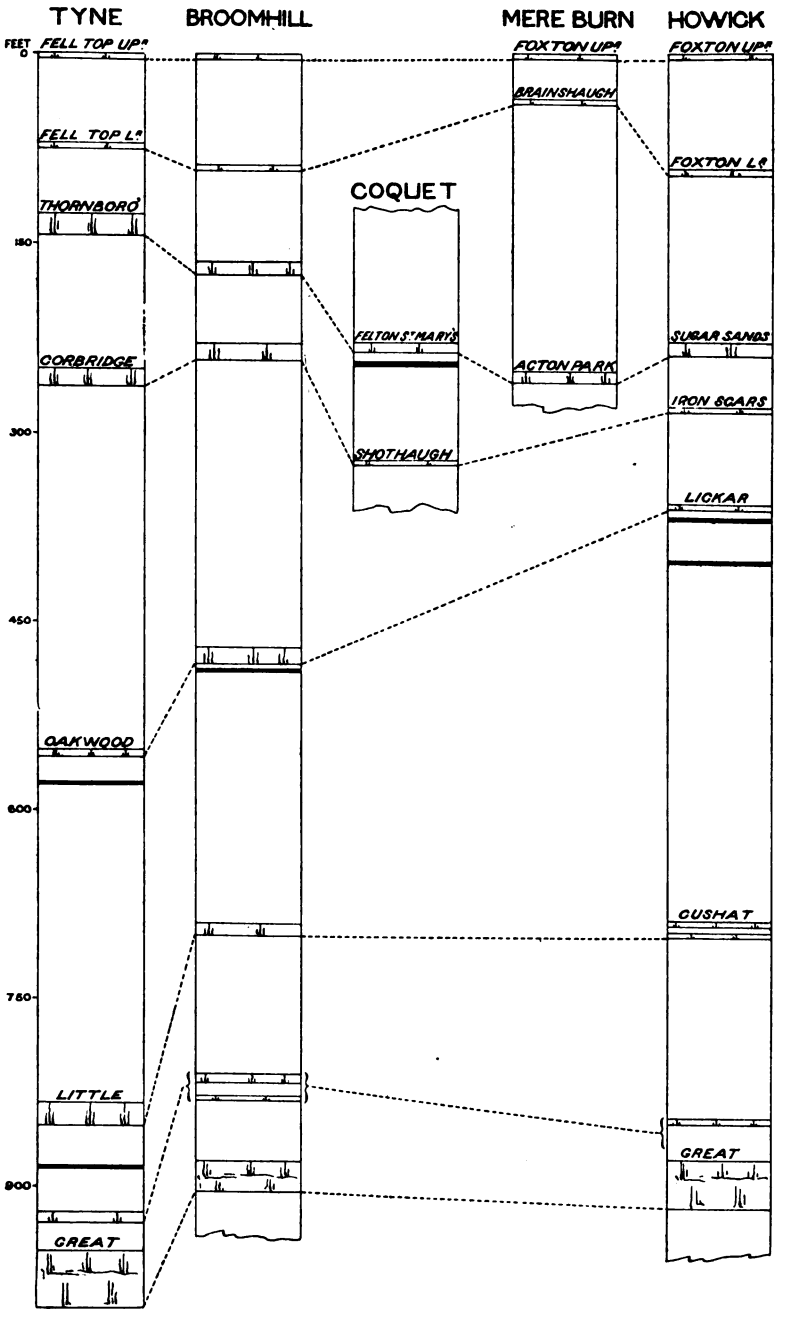

FIG. 5.—*Comparative Vertical Sections of the Upper Limestone Group in Northumberland. Scale, 150 ft. to 1 in.*

Digitized by Google

whole has been well proved north of the Tyne, and the only modification of previous work required is the elimination of the Robsheugh Limestone as a separate bed[1]: it is, in reality, the equivalent of the Thornboro' Limestone. A comparison of the sections (*see* Fig. 5) shows that the Tyne sequence compares well with that of the northern areas: the Fell Top position is in two divisions (Dalton and Harlow Hill) and the only noteworthy difference is in the thickness of the limestones: even here, the third limestone down (the Thornboro'), is the most important, as it is at Howick (the Sugar Sands Limestone). One may remark, in passing, that one or two beds of limy sandstone, often fossiliferous, are known in the Tyne district, but for the sake of clearness they have been omitted from the diagrams, only true limestones of thoroughly marine type being shown. The variations in the intervening strata are remarkably small, when one considers that the sections figured are so far apart.

Coal Measures.—Mr. Fowler, working on the northern limit of the Northumberland Coal Measures around Broomhill, reports that there are seven workable seams, ranging from the Radcliffe down to the Bottom or Yard Coal, and distributed through 1500 ft. of strata. They are all steam coals, there being no commercial distinction between them. The lower seams (the Bottom, Top and Main Coals) are wrought at Broomhill, and the upper ones (from the Princess to the Radcliffe) at Newburgh Pit, 1¼ m. to the west. At least two east-and-west faults of some size are known, one of them, the Bondicarr Fault, 16 fms. down south, ranging from the coast at Bondicarr to a point north of Broomhill. The other fault runs north of Hauxley and has a throw fully 100 fms. down south, forming the northern boundary of the field. There are no exposures of these faults at the surface, information regarding them being obtained from underground workings only.

A large 'wash-out' in the Main Coal at Broomhill, previously mapped by Mr. Topley, leaves the seam towards the east. The Main Coal is normally from 4 to 6 ft. thick, with a band in the middle[2], but within the 'wash-out' area, islands of solid coal up to 9½ ft. thick have been proved by boring. Neighbouring coals are unaffected, although round Hadstone there is reason to suspect that another 'wash-out' in the Queen Coal (one of the higher seams) is present.

No further information has been gathered concerning the well-known Acklington Dyke, but south-east of East Chevington a new igneous intrusion has been proved in working the Top Coal: it has a width of fully 24 ft., and may be a continuation of the Causey Park dyke, known in the Longhorsley district, 6 miles to the south-west.

[1] The assignment of a definite position to this limestone, between the Fell Top and Thornboro' horizons, seems to have been first adopted by Professor Lebour, his view being assented to by Dr. Stanley Smith ('Report . . . on the Carboniferous Limestone Formation of the North of England.' *N. of England Inst. Min. and Mech. Eng.*, 1912, p. 7, &c.)

[2] This parting increases rapidly east of Low Coldrife, and at Newburgh only the bottom coal, locally known as the Duke Coal, can be wrought.

Digitized by Google

In the intervening ground Mr. Maden notes that a sudden stoppage of the coal workings south of West Chevington suggests the presence of the intrusion, this being supported by the termination of the workings in the adjoining Bullock's Hall Colliery in 'cinder coal.' Round Longhorsley he has traced the dyke more than 4 miles further than appears on the published map: it is at present being quarried by the roadside ¼ m. north of Parkhead Farm, Netherwitton.

In the Newcastle district Mr. Maden reports that the 'Forty Fathom' and 'Seventy Fathom'[1] posts are at present worked at South Gosforth and Walker respectively. In the South Gosforth quarries, at Haddricksmill, grindstones of all sizes are the chief product, while at Walker few are made, most of the output being for stone facings: in the past the Walker freestone has been used for leading structures in the city, the Ouseburn Viaduct being a prominent example.

South of the Tyne, between High Felling and Eighton Banks, Mr. Anderson reports that the Seventy-Fathom post (known locally as the Grindstone Sill) must change somewhat in character, for here it is the chief source of the well-known 'Newcastle grindstones.' The 'sill,' approximately 120 ft. thick, has been quarried for 300 years or more: the grindstones are made from two kinds of sandstone, 'blue' and 'brown.' The 'blue' stone, in even beds from 3 to 6 ft. thick, makes up the lower 50 ft. of the 'sill.' It is bluish-white in colour, fine-grained, hard and durable, and has good weathering properties. A homogeneous structure renders it valuable for sculpturing and building purposes, and for the making of Grade I grindstone; tested on a 4 in. x 4 in. x 3 in. block, the crushing load was 4¾ tons per sq. in. The 'brown' stone, forming the upper 70 ft. of the sill, is rather softer and coarser. It gives smaller blocks than the 'blue,' since the uniform structure is greatly affected by false-bedding. This stone is wrought for Grade II grindstone, and its crushing load is slightly less than the 'blue.'

Owing to hardness, the production costs of these grindstones are rather high compared to others, and largely on this account the present-day trade is small. Nevertheless, a world market still holds for Grade I stones, used for grinding rice: and there is a fair export of Grade II stones to America and Scandinavia, where they are used in the manufacture of paper pulp.

Glacial.—In the Wooler district, Mr. Burnett finds that the sands and gravels along the eastern margin of the Hedgeley basin can be traced up the Roddam Dene and Lilburn burns to Calder and South Middleton Moor, but away from these streams are spread but thinly over the boulder clay. The deeply trenched cuts traversing the kettled gravels of this basin often prove to be diversions of present-day streams, the initial divergence being in some cases accompanied

[1] These names refer to distances above the High Main Coal, not to the thickness of the stone.

Digitized by Google

by terraces, such as those at 707 ft. and 715 ft. O.D., about 300 yds. west of South Middleton.

Terrace gravels, much denuded and somewhat ill-defined, are found north-east of Wooler, more or less in line with the road to Kirknewton. The material seems to have been dumped by streams pouring out from the Cheviots into the Wooler-Etal lake, of late-Glacial date.

Mr. Maden has noted several sinuous esker-like ridges of sandy gravel, trending in a general east-and-west direction, on the moorlands south of the Simonside Fells. The origin of these mounds is obscure, owing to the great rarity of sections. There is at least one good cross-section, however, about 2 m. west of Blueburn: at this point the Chertner Burn, making a sharp bend, cuts right across a well-defined ridge, fully 20 ft. high. The bedding towards the outer edge is obscured by scree, but in the centre some of the gravel, preserved by a calcareous matrix, has a distinct horizontal arrangement.

Whatever their origin may be, these ridges seem to be of late-Glacial date, and since at least one of them is cut by the Chertner Burn, the present course of this stream is undoubtedly post-Glacial.

There is an excellent example of a 'truncated spur' at Selby's Cove, near the headwaters of the Blagdonburn Burn; the cut is about 40 ft. deep.[1]

Mr. Fowler has observed east-and-west striations in the Rothbury district 1 mile east of South Cartington, while there are isolated mounds of sand and gravel both along the high ground west of Longframlington and by the Coquet near Rothbury. South of Felton Fence are sections showing an upper boulder clay parted by a sand layer from the ground moraine below. Other stretches of sandy material, interspersed with patches of clay, south-east of Felton, probably mark the northern extremity of Dr. Smythe's 'Crowden Hill Drift Ridge.'[2]

There is a heavy covering of boulder clay over the Coal Measures around Broomhill: from 60 to 80 ft. is the usual thickness, although as much as 156 ft. of clay with sand and gravel is recorded in an old boring south-west of Broom Hill Farm.

On the coast near Bondicarr low cliffs of blown sand cover the remnants of a 'buried forest,' lying about high-water mark. This is probably of much the same date as the one previously recorded at the mouth of the Howick Burn[3]: the blown sand rests on 2 ft. of peat containing stumps of trees, the roots of which penetrate into 3 ft. of greyish clay beneath.

R. G. CARRUTHERS.

---

[1] First noticed by Dr. J. A. Smythe: *see Trans. Nat. Hist. Soc. Northumberland*, vol. iv, 1909–1913, p. 105 and Photograph No. 3.

[2] Smythe, J. A., *loc. cit.*, p. 97.

[3] 'Summary of Progress' for 1922 (*Mem. Geol. Surv.*), 1923, p. 77.

Digitized by Google

(B)—SCOTLAND

1. AYRSHIRE

E. B. BAILEY, M.C., B.A., District Geologist.
J. E. RICHEY, M.C., B.A., Senior Geologist.
V. A. EYLES, B.Sc.
J. B. SIMPSON, B.Sc.
A. G. MACGREGOR, M.C., B.Sc. } Geologists.

In Southern Ayrshire (Sheet 14), Mr. Eyles worked southwards from Ayr, Mr. MacGregor made Patna his centre, Mr. Simpson examined the country between Dalmellington and New Cumnock, and Mr. Richey undertook the little isolated basin of Dailly. Many fossils were collected, and some important results, bearing on North Ayrshire stratigraphy, are discussed in the Palæontological section, p. 124.

Lower Old Red Sandstone.—During the original survey of this district[1], the sediments and lavas of Kirkoswald, Maybole and Brown Carrick were doubtfully placed in the Middle Old Red Sandstone. More recently they have been grouped with the Lower division; and *Kampecaris tuberculata* Brade-Birks[2] has been described from material collected by Mr. John Smith at Dunure.

Mr. Eyles has commenced the revision of the north-eastern corner of the Lower Old Red Sandstone area. The lavas form a group that rests upon a predominantly sedimentary sequence, and the junction is of intercalatory character. As observed by Sir Archibald Geikie, many of the lavas are slaggy and have their cracks filled with sandy sediment.

Upper Old Red Sandstone.—Recurrence of Upper Old Red Sandstone facies at various levels in the Calciferous Sandstone of South Ayrshire, combined with scarcity of fossils, introduces a very difficult problem. For the present it is assumed that the commencement of the Carboniferous in this district is marked by the earliest interstratification of a distinctive Carboniferous type of sediment. This leaves a very considerable mass of sandstone, etc., to be classed as Upper Old Red Sandstone—including all the quarried cornstones of the county.

On the one-inch geological map (Sheet 14, 1868), the Calciferous Sandstone is shown extending from the Heads of Ayr inland for six miles to Dalrymple, and is separated into an upper group of shales and cementstones and a lower group of red sandstones with corn-

[1] Geikie, A., *in* 'Ayrshire: Southern District' (Explanation of Sheet 14), (*Mem. Geol. Surv.*), 1869, p. 12.
[2] Brade-Birks, S. G., 'Notes on Myriapoda, XXVIII,' *Proc. Roy. Phys. Soc.*, vol. xx, 1923, p. 277.

Digitized by Google

stones. Mr. Eyles regards the latter, with minor modifications of boundary, as belonging to the Upper Old Red Sandstone. Palæontological proof of the presence of Upper Old Red Sandstone appears to be afforded by a record of *Bothriolepis major* (Ag.) [*Pterichthys* Auct.[1]] from the coast south of Heads of Ayr. The original field map clearly marks the locality as within the area of the rocks now placed in the Upper Old Red, although the Sheet Explanation placed it with older rocks. South of Dalrymple and Loch Martnaham, the Red Sandstone outcrop of the published map often includes, not only Upper Old Red Sandstone, but also the Cementstone Group and the Upper Calciferous sediments. Exposures are poor, but are supplemented by bores, and the main features of the stratigraphy have now been cleared up. A good exposure of conglomeratic sandstone, referred by Mr. MacGregor to the Upper Old Red Sandstone occurs along the River Doon in Boreland Glen, 1½ m. N.N.W. of Patna. It contains a worked cornstone over 6 ft. thick.

Cementstone Group.—Mr. Richey has furnished the following account of Passage Beds between the Upper Old Red Sandstone and the main part of the Cementstone Group. An exposure in the Lindsayston Burn, ½ m. E.S.E. of New Dailly, consists for the most part of bedded reddish sandstones, frequently calcareous. In the lower part, cornstones overlain by grey-green marly shales are interbedded at intervals; in the upper part cornstones are absent and partings and beds of marly shale frequent. Above these, and just east of a roadside cemetery, occurs a thick mass of shales with bands of cementstone and fine-grained sandstone, quite characteristic of the Cementstone Group. Somewhat similar passage beds at the base of the Cementstone Group have been noted in other parts of Scotland[2]. The New Dailly section, however, is of particular interest, since it shows typical cornstone concretions in the lower part of the passage beds, a feature that is not known outside of South Ayrshire. A very significant sequence—(1) cornstone, (2) marly greenish shale, (3) thick sandstone—is repeated at three levels in the New Dailly section, and is found in other exposures of the district.

Mr. Richey finds the more characteristic part of the Cementstone Group well developed in the country surrounding the Dailly coalfield. On the north-west side, in a stream ¼ m. N.N.W. of Pathhead, he collected shells which Dr. Lee assigns to *Anthracomya minima* Ludwig.

Farther north-east, on the margin of the Patna Coalfield, Mr. MacGregor finds the Cementstone Group exposed in Meikleholm Glen. A bore about a mile south-east of Patna seems to have passed through 70 or 80 fms. of the group. Another bore, three miles south-east of Ayr, penetrated 55 fms. In neither case was the base reached.

[1] Geikie, *op. cit.*, p. 13.

[2] Peach, B. N., and J. Horne, 'The Canonbie Coalfield,' *Trans. Roy. Soc. Edin.*, vol. xl, part iv, 1903, p. 841; Bailey, E. B., *in* 'The Geology of the Glasgow District,' (*Mem. Geol. Surv.*), 1911, p. 10, second edition 1925, p. 11.

Digitized by Google

From a collection made by Mr. Manson from the well-known coastal exposure at the Heads of Ayr, Dr. Lee has determined *Lingula mytiloides* J. Sow., *Estheria striata* (Münster), *Anthracomya minima* Ludwig, and fish remains. *Lingula* does not seem to have been previously found in the Cementstone Group of Western Scotland, except in a bore not far from Ayr.

Upper Calciferous Sandstone.—Mr. Richey finds strong evidence for a recurrence of Upper Old Red Sandstone conditions during part of the time-interval between the Cementstone Group and Lower Limestones of the Dailly coalfield. The stream that yielded *Anthracomya minima* from the Cementstone Group, on the north-west side of the basin, shows an apparent upward succession into sandstones, conglomerates, and marls with cornstone concretions, all of Upper Old Red Sandstone character—except that some of the sandstones contain plant-remains. On the other side of the basin similar red sandstones and marls with cornstone concretions are exposed in a stream in the grounds of Bargany House, between outcrops of the Cementstone and Lower Limestone Groups.

This evidence is confirmed by bores in the Patna and Loch Martnaham districts. About 30 fms. of reddish grey, brown or white sandstones, interbedded with red marl, or reddish fakes and blaes intervene between the Cementstone Group and the Lower Limestones. A thin coaly layer has sometimes been found 8 fms. down in the sequence. The most important exposure of the group has been identified by Mr. Eyles in a roadside quarry 700 yds. west of Kersepark Farm.

This peculiar South Ayrshire facies extends north-west to Loch Martnaham but disappears before reaching Ayr.

Lower Limestone Group.—At Dailly, Patna and Loch Martnaham, the Lower Limestone Group is thin and contains two limestone positions. The lower of these (Captain's Bridge or Patna Limestone) has been extensively worked. The upper is known to be exposed only in the Dailly coalfield. Mr. Richey describes it as consisting of limy shales with encrinites and gastropods, associated with two or more thin dark limestones. The Captain's Bridge Limestone is compared by Mr. Richey with the Dockra (Hurlet) Limestone of North Ayrshire, and the upper calcareous zone with the two Upper Hosie Limestones (C and D) of the same district.

A remarkably sudden diminution affects the Carboniferous Limestone and Millstone Grit Series on crossing a line of faulting that separates Patna (5, Fig. 6) from Loch Martnaham (2, Fig. 6; this figure is based upon several bores and does not precisely correspond with the thicknesses quoted in the text). The total thickness of the two series dwindles from 237 fms. to 47 fms. within a distance of two miles. Most of the change occurs in the relatively thick groups that overlie the Lower Limestones. In the Lower Limestone Group the reduction is from 12 fms. to 5 fms. The change must be corre-

Digitized by Google

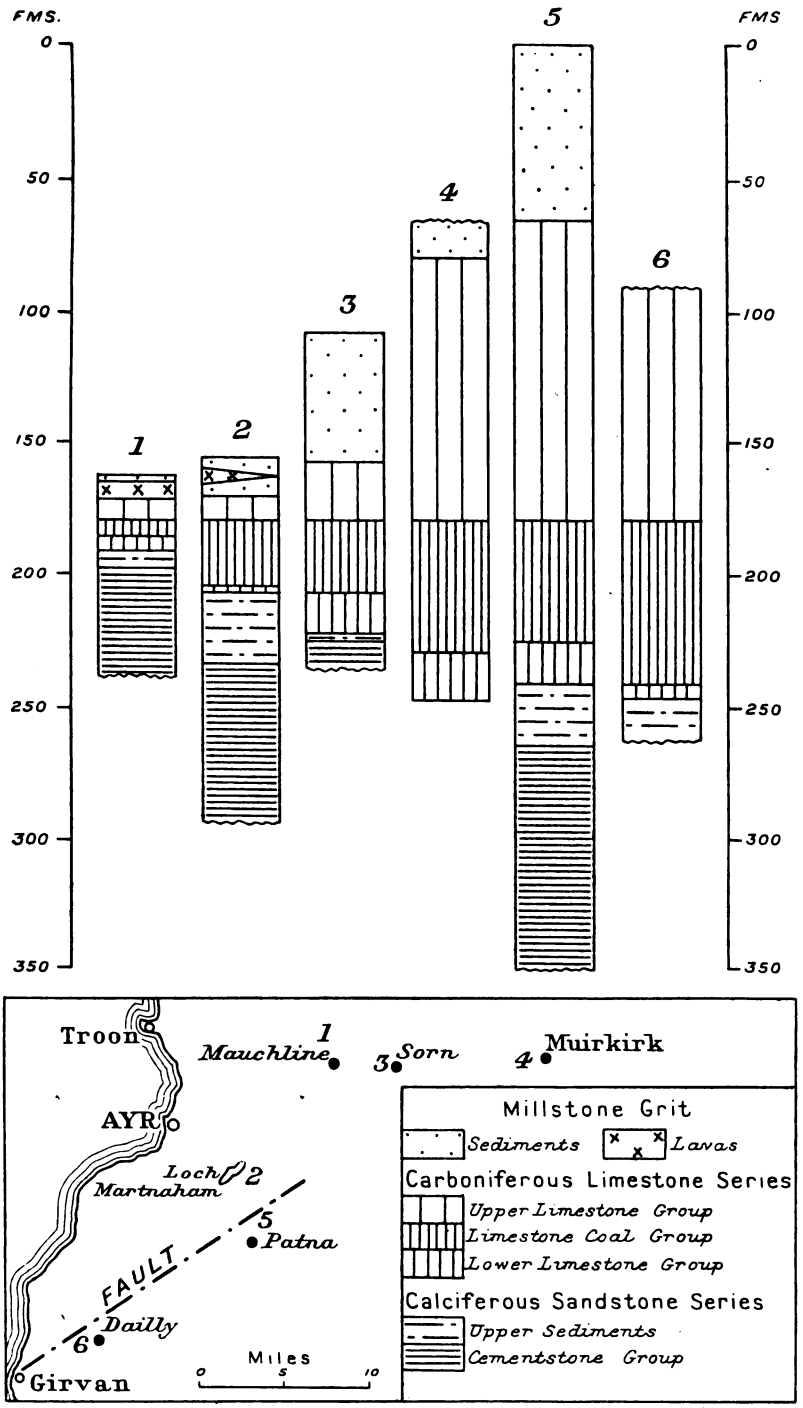

FIG. 6.—*Comparative Sections, South Ayrshire.*

Digitized by Google

lated with differential movement during sedimentation as Prof. Dron[1] pointed out more than twenty years ago, though he confined his attention to the coal developments in the Limestone Coal Group of the district. Mr. Anderson[2] has recently discussed similar phenomena in Central and North Ayrshire.

Limestone Coal Group.—Mr. Richey reports that the thickness of the group varies from about 60 fms. in the north-east part of the Dailly field to 30 fms. at the south-west extremity. In the lower part of the sequence, thin seams of coal and fireclay are interbedded with sandstone (Captain's Glen). Beds of shale with clayband ironstone are not found, and the sequence thus differs from that of Renfrewshire and North Ayrshire. In the middle portion six workable coal seams occur, which are constant over the Dailly field so far as proved by mining operations. A thick sandstone is met with at the top of the sequence.

Mr. MacGregor gives the thickness of the group as 43 fms. near Patna and 33 fms. near Waterside. The well-known Patna Coal serves as a convenient index throughout. There are several very thin coals, and one named seam, the Stinking Coal, between the Patna Coal and the Lower Limestones. The Patna Coal consists of 10 to 18 ft. of coal with partings. A fathom higher, in the region of maximum development, lies the impure Smithy Coal. The top part of the group above the Smithy Coal consists near Patna of sandstone as at Dailly. This sandstone is 20 fms. thick, but is replaced by 4 fms. of shales, etc., in the gorge below Keirs Castle.

In common with the rest of the Carboniferous Limestone Series, the Limestone Coal Group undergoes an abrupt thinning near a belt of faulting that runs north-east past Kerse Loch between the Patna and Loch Martnaham areas. The change has been carefully investigated by Mr. MacGregor and Mr. Eyles. The Patna side of the fault has been mined to some extent, and there is plenty of boring information. A thickness of about 43 fms. for the Limestone Coal Group (5, Fig. 6) obtains at Houldsworth Colliery, while two miles farther north, at Southcraig Farm, the thickness is only 16 fms. Comparison with adjoining bores shows that the diminution in thickness at Southcraig is characteristic of the district (2, Fig. 6).

Upper Limestone Group.—The Dailly and Patna coalfields agree in having a thick Upper Limestone Group with an unusual number of limestones. Exposures are poor and almost all the evidence has been obtained from bores. At Dailly, Mr. Richey has examined the deepest shaft and proved that the Millstone Grit is not in the basin. The Upper Limestone Group, as preserved, reaches about 90 fms. in thickness, including six beds of limestone. The third limestone from the base is 20–30 ft. thick.

In the Patna field, the group varies in thickness up to 117 fms.,

[1] Dron, R. W., 'The Coalfields of Scotland,' 1902, p. 11.

[2] Anderson, E. M., *in* 'Economic Geology of the Ayrshire Coalfields, Area II' (*Mem. Geol. Surv.*), 1925, chap. v.

Digitized by Google

with as many as 12 limestone horizons. The limestones are variable, but can be correlated with fair certainty in bores. A particularly thick bed is found round Waterside, sometimes second, sometimes third in the sequence, reckoned from the base.

Mr. MacGregor cites the following as an extreme case of variation in a limestone. West of a north and south line through Waterside Church, the thick limestone referred to is second in the sequence. East of the line, an important extra limestone comes in below it. The extra limestone is known to persist for at least half a mile eastwards. It is never less than 7 ft. thick, while in one bore it is represented by two limestones 7 ft. 9 in. and 7 ft. 3 in. thick, with a 10-ft. parting of limy fakes.

The thinning of the Upper Limestone Group in the two miles separating the Houldsworth Colliery of the Patna field and Southcraig Farm of the Loch Martnaham area is particularly marked, resulting in a reduction from 117 fms. (5, Fig. 6) to 6 fms. (2, Fig. 6); the thinning affects all types of sediment uniformly.

Millstone Grit.—The strata between the top limestone of the Upper Limestone Group and the Burnfoot Blackband Ironstone are classed as Millstone Grit. The division undergoes similar rapid changes in thickness at the belt of faulting passing Kerse Loch. At Lethanhill in the Patna field, Mr. MacGregor reports 65 fms. of Millstone Grit (5, Fig. 6), while, near Southcraig Farm in the Loch Martnaham area (2, Fig. 6), Mr. Eyles finds only 20 fms. A bore starting below the top of the Millstone Grit 400 yds. south of Houldsworth Colliery pierces 60 fms.; hence the reduction from 65 to 20 fms. takes place within a distance of 2 miles.

The Millstone Grit of the Patna field includes a strong development of poor thin coals, thick fireclays, and shales (blaes) with clayband ironstones, and some sandstone. The best known horizons are the Dunaskin Rock (sandstone) with the Dunaskin Clayband Ironstone and the Dunaskin Fireclay. The Dunaskin Clayband was formerly mined in the Drumgrange Burn, 1,000 yds. north of Waterside.

The Arran and Ayrshire lavas of Millstone Grit age terminate south-eastward along a line that passes near Mauchline and a little to the east of Loch Martnaham. Within the area of their development, Mr. Eyles identifies certain lavas at Longhill Point on the Ayr coast as belonging to the horizon.

Coal Measures.—Attention may be directed to important new observations in regard to Skipsey's Marine Band which is taken to mark the upper limit of the Productive Measures. The bed is well known in Tongue Glen, Craigmark, near Dalmellington.[1] During the past season, Mr. Simpson had found an exposure in a stream at Burnfoot Farm, near Bank, New Cumnock. He has also recognised

[1] Smith, J., 'Marine Fossils in Upper Coal Measures,' *Geol. Mag.*, 1906, p. 283.; Smith, J., and C. T. Clough *in* 'Summary of Progress' for 1907 (*Mem. Geol. Surv.*), 1908, p. 132.

Digitized by Google

the horizon in a bore on Chalmerston Hill, Dalmellington, and Mr. MacGregor has identified it in another bore north-east of Patna. The principal characteristic is a hard bed of dark earthy limestone which effervesces with acid. Marine fossils are often inconspicuous.

Skipsey's Marine Band is about 10 fms. above the position of the Craigmark Ironstone of the Dalmellington and Patna district. The identification of this band near New Cumnock may facilitate correlation between the Coal Measures of New Cumnock and Dalmellington.

Another important point follows from Mr. Simpson's discovery near New Cumnock. Coals have been worked under Skipsey's Band at the Afton Colliery, and it is thus possible to fix the Skipsey horizon in the shaft section of the No. 1 Rigfoot pit. In this section, 133 fms. of strata must overlie Skipsey's Marine Band. The top 89 fms. are devoid of coal seams; but, in the lower 44 fms., there are seven coals, all over 1 ft. thick, and two of them measuring 2½ and 3 ft.—none has been worked. Subordinate coal seams have been met with elsewhere in Central Scotland above Skipsey's Marine Band, but never in such strong development.

Necks.—The writings of Sir Archibald Geikie and Dr. Tyrrell have rendered Ayrshire volcanic necks very familiar to geologists. Mr. MacGregor has examined about fifteen of these necks in the neighbourhood of Patna, where they break through rocks as diverse in age as Upper Old Red Sandstone and Barren Red Coal Measures. Several of them contain abundance of peridotite fragments, ranging up to 1 ft. in diameter. All the minerals except a red-brown spinel are commonly replaced by carbonates. The Patna bombs may be compared with lherzolite boulders described by Dr. Tyrrell[1] from the Heads of Ayr vents.

The magma of the Patna necks, represented by bombs and intrusions, is monchiquitic. Some of the intrusions are highly xenolithic and contain numberless small inclusions of sediment and decomposed peridotite. The highly altered character of the peridotite blocks both in the ashes and intrusions suggests that they have been attacked by gases or solutions connected with an early stage of the explosive phase. At any rate, it is practically certain that the change is not due to subaerial weathering, for a sliced specimen from a xenolithic dyke collected more than 200 fms. under ground shows olivine phenocrysts and peridotite enclosures very highly altered.

E. B. Bailey.

[1] Tyrrell, G. W., 'The Geology of the Ayrshire Coast from Doonfoot to the Heads of Ayr.' *Trans. Geol. Soc. Glasgow*, vol. xvi, 1920, pp. 348, 357–9.

Digitized by Google

2. LANARKSHIRE (CHIEFLY): STRATHAVEN, TINTO AND DOUGLAS DISTRICTS.

M. MACGREGOR, M.A., B.Sc., District Geologist.
E. M. ANDERSON, M.A., B.Sc., Senior Geologist.
H. H. READ, D.Sc., A.R.C.Sc.
G. ROSS, B.Sc.
J. PHEMISTER, M.A., B.Sc.
} Geologists.

Field-work was carried on during 1924 in one-inch Sheet 23. Mr. Phemister completed the revision of the Calciferous Sandstone lavas along the western margin of the Sheet, and Mr. Ross that of the Carboniferous rocks of Coalburn and Bankend. They were then transferred to the Douglas Coalfield and have examined that part of it which falls within one-inch Sheet 23. Considerable progress has also been made with the revision of the pre-Carboniferous rocks. Dr. Read has mapped the ground around Tinto between Pettinain and Roberton. Mr. Phemister re-examined the Lower Old Red sediments and lavas around Roberton Law and Wildshaw Hill on the east side of the Douglas valley. Mr. Ross continued his field-work on the Silurian and Lower Old Red Sandstone rocks round Nutberry and Hagshaw Hills to the west and south-west of Bankend. The results obtained are summarized below by the officers concerned.

Mr. E. M. Anderson has been engaged under Mr. E. B. Bailey in the preparations of maps, sections, and memoirs dealing with the Ayrshire Coalfield. Mr. Macgregor has prepared for publication second editions of 'Economic Geology of the Central Coalfield, Area V' (Coatbridge and Airdrie district) and of 'The Geology of the Glasgow District,' which are now in the press. In the latter task he has had the assistance of Messrs. C. H. Dinham, E. B. Bailey and E. M. Anderson. A considerable number of borings at different localities in the Central Coalfield have also been examined during the year.

The ground revised by Dr. Read between Pettinain and Roberton in the south-east part of Sheet 23 is shown in Fig. 7 (p. 98). The sedimentary rocks, with the exception of the small outlier of Carboniferous sediments at Newton, belong to the Ordovician, Silurian and Lower Old Red Sandstone formations. Important suites of effusive and intrusive igneous rocks of Lower Old Red Sandstone facies are also present. Dr. Read supplies the following paragraphs regarding this area :—

Ordovician.—The Southern Upland Fault crosses the south-east corner of the area, from Lamington to Roberton. The Ordovician rocks lying to the south-east of this dislocation consist chiefly of greywackes, slates and grits with conspicuous bands of the fine conglomerate known as the Haggis Rock. Four new localities of

Digitized by Google

fossiliferous black shale have been discovered, from two of which an extensive collection of graptolites has been made by W. Manson and W. E. Strachan. The collected localities are in the Hartside Burn, 1100 and 1400 yds. up from Hartside. The graptolites have not yet been determined but they indicate Hartfell and Glenkiln horizons.

Upper Silurian.—The table given below shows in descending order the rock-groups of the Upper Silurian and Lower Old Red Sandstone formations within the area examined :—

Lower Old Red Sandstone	Lava-conglomerate
	Sandstone
	Ashy sandstone
	Lavas, chiefly andesitic
	Sandstone
	Greywacke-conglomerate
Downtonian	Sandstone
	Quartzite-conglomerate
	Sandstone, with Fish-bed position
	Conglomerate of igneous pebbles
Ludlow	Green Shale with *Beyrichia*, etc.
	Sandstone

The distribution of the various members of this sequence can be made out from Fig. 7.

Rocks belonging to the Ludlow Series were noted by Drs. Peach and Horne[1] in the bed of the reservoir at Eastfield, south of Tinto, where hard greenish-grey greywackes and shales were at that time visible. In the Carmichael Burn, 250 yds. south of the manse, there is a good exposure of green mudstones which dip below the conglomerate with igneous pebbles taken as the base of the Downtonian. These shales were first described by Sir Archibald Geikie[2] and have furnished specimens of *Monograptus, Beyrichia kloedeni, Dithyrocaris striata,* and *Orthoceras dimidiatum.*[3] Farther upstream are a few small exposures of fine-grained red, yellow and grey sandstones.

The basal member of the Downtonian Series is taken to be a conglomerate made up almost wholly of igneous pebbles. It is not seen in the Downtonian area south of Tinto, but is fairly well exposed in the Carmichael Burn, following immediately on the Ludlow mudstones just described. It is a fine conglomerate or pebbly sandstone with a coarse greenish matrix ; its thickness is probably at least 100 ft. The pebbles are usually less than one inch in diameter

[1] Peach, B. N., and J. Horne, ' The Silurian Rocks of Britain : Vol. I. Scotland ' (*Mem. Geol. Surv.*), 1899, p. 588.

[2] Geikie, Sir A., ' Lanarkshire (Central Districts),' (Explanation of Sheet 23) (*Mem. Geol. Surv.*), 1873, p. 14.

[3] Peach, B. N., and J. Horne, *op. cit.*, p. 586.

Digitized by Google

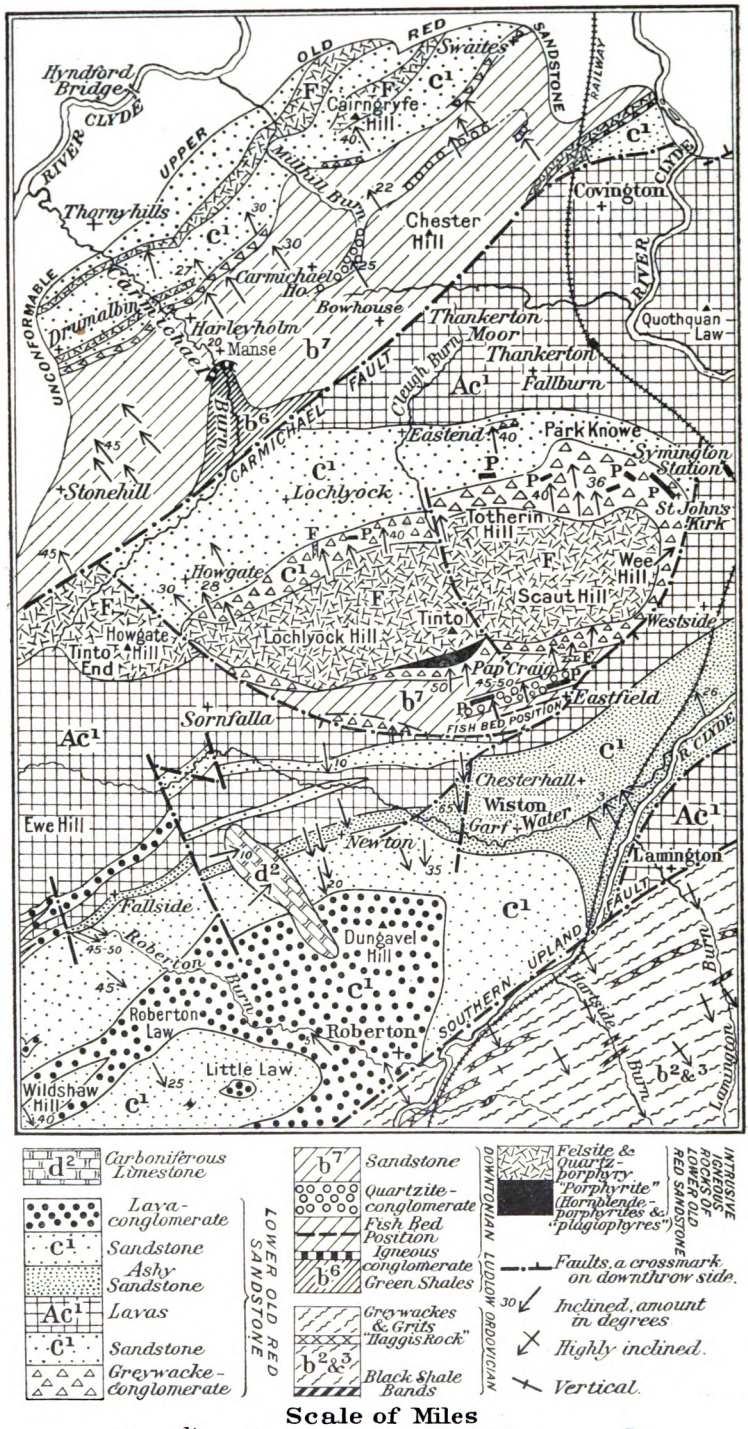

FIG. 7.—*Geological Map of the Tinto District, Lanarkshire.*

Digitized by Google

and consist of white and pink granitic rocks, acid volcanic rocks, porphyries, felsites, and green basic rocks possibly spilitic, with a few of quartzite, grit and jasper.

The beds between this conglomerate and the Quartzite-conglomerate are not well seen in the area south of Tinto, but here Drs. Peach and Horne[1] found, in the fields north-west of Eastfield, green mudstones and shales which elsewhere contain the Downtonian fish fauna. In the Carmichael district no trace of the fish-bed has been found, the beds in this position consisting of fine-grained grey sandstone with scattered pebbles of quartzite, granite, jasper, chert, etc. The Quartzite-conglomerate, the most notable member of the Downtonian of this area, is well developed both in the ground south of Tinto and in the Carmichael district. South of Tinto it is seen in a line of old quarries stretching from ⅔ mile west to ⅛ mile north-west of Eastfield. It is locally exceedingly coarse and made up chiefly of large well-rounded pebbles of quartzite. Traced westwards, the conglomerate interdigitates with coarse gritty layers and is replaced at the western end of the outcrop by buff sandstones with thin layers of coarse conglomerate. In addition to the quartzite pebbles, there are many of chert, jasper, various Southern Upland rocks, and igneous rocks. Among the latter, there have been noted over a dozen different types of acid igneous rocks. An estimate gave 10 per cent. of igneous pebbles. The thickness of the Quartzite-conglomerate here must be over 300 ft. In the Carmichael district the Quartzite-conglomerate is found on the summit of Kirk Hill ⅓ mile east of Carmichael House, and shows characters exactly like those of the conglomerate south of Tinto. From here, the conglomerate, dipping steadily north-west at moderate angles, can be traced north-eastwards for 1½ miles until it is lost in the drift-covered moor south of Swaites. A second and smaller outcrop is found ¾ mile south of Swaites and dips also to the north-west. This may possibly be due to folding rather than to faulting. South-west of Kirk Hill the Quartzite-conglomerate has not been definitely recognised, but in the Carmichael Burn below the manse and on the ridge east of Stonehill, there are many thin bands of quartzite-conglomerate intercalated with grey pebbly sandstones.

Above the Quartzite-conglomerate and forming the uppermost Downtonian beds, there are, in the area south of Tinto, flaggy chocolate, green and purple sandstones lying below the Greywacke-conglomerate. In the Carmichael district these beds are represented by grey felspathic sandstones with scattered quartzite pebbles, well seen, for instance, on the hill-slopes above Carmichael House.

Lower Old Red Sandstone.—The Greywacke-conglomerate, taken as the basal member of the Lower Old Red Sandstone, is well developed in the Tinto and Carmichael districts. In the former, it is of considerable thickness, and forms the floor and roof of the great felsite laccolith of Tinto. It is a coarse conglomerate whose dominant

[1] Peach, B. N., and J. Horne, *op. cit.*, p. 588.

Digitized by Google

pebbles are of greywacke and various Southern Upland grits together with a few of quartzite, jasper, chert, and igneous rocks such as granite, porphyry and felsite. In the Carmichael district the Greywacke-conglomerate can be followed for four miles from Drumalbin north-eastwards to near Swaites and resembles the Tinto exposures, but is considerably thinner, its maximum thickness being about 150 ft. In the railway cutting 1¾ miles north of Thankerton Station there is a small exposure of the Greywacke-conglomerate dipping north-north-westwards, possibly due to folding.

The beds intervening between the Greywacke-conglomerate and the lavas are purple, chocolate or reddish sandstones with occasional thin bands of Greywacke-conglomerate.

The volcanic rocks appear to follow normally on these sandstones in the district around Thankerton, but on the south and east of Tinto the junction between lavas and older rocks is a faulted one (Fig. 7). The lavas are dominantly of andesitic character; basaltic and apparently trachytic lavas are rarer, though at Quothquan Law and farther east towards Biggar the last type becomes fairly common. The rock of Quothquan Law is a fine-grained purplish or lilac-coloured rock with marked flow-structure and was interpreted by Sir A. Geikie[1] as a plug, but detailed mapping appears to show that it is a thick lens-shaped flow dipping northwards. The lavas of the Tinto district resemble those of similar age in the Pentland Hills and are much decomposed.

Beds of agglomerate or tuff are rare, but a 10-ft. bed of ash is well seen in the Clyde, 1¼ miles east-south-east of Thankerton Station. Amongst the lavas there are many thin bands of sedimentary material and, south of Tinto, thickish beds of sandstone and lava-conglomerate occur towards the top of the volcanic zone.

In the Wiston district the lavas are succeeded by a coarse green ashy sandstone well seen, for instance, in the Garf Water below Wiston and in the Clyde below Lamington. From Wiston this zone, considerably reduced, can be traced to Newton. Above the ashy sandstone there are exposed at the northern foot of Dungavel Hill flaggy purple and grey sandstones with thin beds of lava-conglomerate. These beds pass upwards into the Lava-conglomerate which builds Dungavel Hill. This conglomerate is exceedingly coarse; its pebbles are commonly over 1 ft. in diameter and occasionally reach 3 ft. They are all well rounded and consist entirely of lavas derived from the volcanic zone below. Good exposures are seen in the Roberton Burn at Roberton. Thick lenticular masses of sandstone lying within the Lava-conglomerate are exposed in the Roberton Burn and its tributaries. The main mass of the Lava-conglomerate is followed by chocolate and purple sandstones and these, on Little Law, by a bed of higher lava-conglomerate occupying the centre of the Roberton syncline.

---

[1] Geikie, Sir A., 'Ancient Volcanoes of Great Britain,' vol. i, 1897, pp. 288, 328, fig. 92.

Digitized by Google

Tectonics.—The Upper Old Red Sandstone rests unconformably upon the older rocks along the northern border of their outcrop as indicated in Fig. 7. Before its deposition, the older rocks were folded, faulted and possibly thrust. Though the only dislocation which is demonstrably older than the Upper Old Red Sandstone is the Carmichael Fault, it is probable that the dislocation passing east of Howgate Hill and limiting the Downtonian area south of Tinto is also of this age. The Carmichael area of Ludlow, Downtonian and Lower Old Red Sandstone rocks can be interpreted as an anticlinal fold, the south-eastern limb of which has for the most part been cut out by the Carmichael Fault. The double outcrop of the Quartzite-conglomerate, the Greywacke-conglomerate and its attendant felsite sills in the ground north of Covington, and the constant northern and north-western dips in this area, suggest that this part of the anticline is overfolded. This has been hinted in Fig. 7 by a line connecting the two outcrops of the Quartzite-conglomerate in this district and possibly the two outcrops of Greywacke-conglomerate connect with one another beneath the cover of Upper Old Red Sandstone. This recognition and interpretation of the Carmichael Fault recalls the reversed fault affecting similar rocks in the Hagshaw Hills,[1] 10 miles to the south-west. It is practically certain that the Hagshaw and Carmichael Faults are one and the same, and the overfolding of the rocks in the Covington area is a not unlikely accompaniment of the thrust-movements that have taken place along this dislocation. North-eastwards this thrust-line disappears beneath Upper Old Red Sandstone and younger rocks, but it will probably be encountered at the east side of the Pentland Hills in Midlothian.

The long felsite ridge of the Tinto Hills is breached, at Howgate Mouth east of Howgate Hill, by a deep gully eroded in part along a fault-breccia formed by a dislocation that passes through the Mouth and limits the Downtonian area south of Tinto. The more southerly outcrop of the Greywacke-conglomerate in this area is interpreted in Fig. 7 as due to the splitting of this fault with the infaulting of a small wedge of the conglomerate. An alternative explanation is that overfolding has taken place above the Howgate Mouth Fault and that the southern exposure of Greywacke-conglomerate represents the lower limb of a reversed anticline. The ground is poorly exposed and the two outcrops of Greywacke-conglomerate cannot be shown to connect, but, since the Quartzite-conglomerate outcrop shows no signs of turning round in sympathy with such a supposed reversed anticline, it has been considered better to suggest the explanation given in Fig. 7.

In the southern part of the district the lavas, ashy sandstone, sandstone and lava-conglomerate are disposed in a syncline with an axis passing through Little Law north-eastwards to the Clyde.

Intrusive Igneous Rocks of Lower Old Red Sandstone Facies.—Into the Upper Silurian and Lower Old Red Sandstone

[1] Peach, B. N., and J. Horne, *op. cit.*, p. 581, and fig. 118, p. 584.

Digitized by Google

are intruded a series of igneous rocks, mostly of sill-form. The period of intrusion is earlier than the Upper Old Red Sandstone which transgresses, for instance, the felsite sills of Cairngryfe Hill and incorporates in its basal breccia abundant material derived from these. The igneous intrusives fall into two classes; the first and more important may be termed felsites, the second porphyrites.

The great felsite of the Tinto Hills is typical of the first group. This felsite is intruded into Greywacke-conglomerate and this horizon appears to be one favoured by felsite intrusion, for all its exposures in this district are accompanied by a series of felsite sills which are probably outlying parts of the Tinto intrusion. Leaving out of consideration for the time being that part of the Tinto felsite lying west of the Howgate Mouth Fault, one sees that the felsite of Lochlyoch, Tinto and Scaur Hills has the form of a laccolith dipping to the north. The laccolith floor is well seen on the south side of the Tinto ridge where Greywacke-conglomerate passes under the felsite. The eastern termination of the laccolith can be mapped with considerable definiteness east of Scaut Hill, and its blunt laccolithic form is evidenced by the disposition of the Greywacke-conglomerate at St. John's Kirk. The roof of the laccolith is similarly formed by the conglomerate all along the northern slopes of the Tinto ridge. Assuming that the average dip of the laccolith is 45°, one finds that the thickness of the felsite is about two thirds of a mile. On the west the Tinto portion of the felsite appears to be dying out naturally near the Howgate Mouth Fault. West of this fault felsite reappears in great thickness on Howgate Hill and Tinto End, but it is here in contact on its south side with lavas, and the boundary between the two is sufficiently clear to show that the relation is intrusive. The floor of the felsite is irregular and there are small satellitic intrusions below the main body. This renders the possibility of the junction being a thrust or faulted one very unlikely, and the Howgate Hill mass of felsite must be considered as lying at a higher horizon than the Tinto mass.

Thin sills of felsite and related rocks occur near the Greywacke-conglomerate in the Carmichael district and in the railway cutting at Covington. These sills have been quarried at many points and a very large quarry is at present operating on Cairngryfe Hill, the metal being trammed to the railway near Pettinain.

The rock of the Tinto laccolith is very uniform, the only variation being caused by the sporadic occurrence of small plates of biotite. It is pink and usually weathered; in slice it is seen to consist of a few phenocrysts of acid plagioclase, biotite and rare quartz in a felsitic base. Similar rocks make up the Carmichael sills.

The second group of intrusions may be loosely classed as porphyrites. The largest occurs beneath the Tinto felsite at Pap Craig (Fig. 7), but smaller sills and dykes are found all round the felsite laccolith. They include hornblende-porphyrites, malchites and transitional forms between malchite and plagiophyre. Many of these intrusions consist of dominant oligoclase laths with scarce

Digitized by Google

mafic components, iron oxides and a little interstitial quartz; the structure is trachytic and there are a few oligoclase phenocrysts in this base. Such rocks resemble the plagiophyres as figured by Dr. G. W. Tyrrell.[1] The Pap Craig sill has a thickness of 240 ft. and is somewhat variable in composition. Its top and bottom consist of quartz-plagiophyre, but the central portion is much richer in the mafic constituent (pyroxene) than usual.

Mr. Ross has continued the re-mapping of the northern portion of the Lesmahagow Inlier southwards to Nutberry Hill, and that of the Hagshaw Hill Anticline westwards to near Monk's Water. Both areas are fully described by Drs. Peach and Horne in Chapter XXIV of 'The Silurian Rocks of Scotland' (*Mem. Geol. Surv.*, 1899) and little can be added to their account of the structure and sequence. The Quartzite-conglomerate, of which a fine section is seen in the Smithy Burn half a mile south-south-east of Hagshaw Hill, has been traced eastwards to a hitherto unrecorded exposure about three quarters of a mile west of Windrow Hill. Near this point the conglomerate has apparently been shifted northwards by faulting for a distance of nearly 500 yds. and reappears in the Windrow Burn, west of Windrow Hill. The Greywacke-conglomerate is well seen near the head of the Hagshaw Burn dipping north at about 30° but where again met with to the east in the headwaters of the Shiel Burn it lies nearly half a mile north of its former line of strike. The dislocation thus indicated is probably a continuation of the fault shown on the one-inch map crossing the Poniel Water south-east of Bankend, where it brings down the Limestone Coals on the west against strata near the base of the Calciferous Sandstone Series. The line of this fault is now continued southwards from Poniel Water along the west side of Burnt Rig to a point about half a mile west-south-west of Windrow Hill.

The constituents of the pebbly bands at the top and bottom of the Quartzite-conglomerate are chiefly vein quartz. The boulders and pebbles of the conglomerate beds are mainly well-rounded, hard, fine-grained, pink and purplish quartzites; the remainder, about ten per cent. of the whole, comprises coarse red granites, red felsites and porphyrites, andesites and spilites, schistose rocks and jasper. The quartzite boulders are sometimes over a foot in diameter.

Mr. Phemister's survey of the Old Red Sandstone rocks on the east side of the Douglas valley was carried eastwards to join up with Dr. Read's work to the south of Tinto (*see* p. 100 and Fig. 7). Mr. Phemister finds that the lavas are mostly dark grey or purplish rocks, varying in structure from slaggy amygdaloidal to compact fine-grained or quite coarsely crystalline types, and are generally in a fair state of preservation. Many show small black or red pseudomorphs after some porphyritic ferromagnesian mineral.

[1] Tyrrell, G. W., 'A Petrographical Sketch of the Carrick Hills, Ayrshire,' *Trans. Geol. Soc. Glasgow*, vol. xv, part i, 1914, p. 64.

Digitized by Google

The phenocrysts of felspar are usually small. A characteristic feature of the Old Red Sandstone lava suite in this district is the occurrence of intercalations of ashy sandstone or grit and of conglomerate composed entirely of pebbles and boulders of lava. These beds may be quite thin or may attain a thickness of about 150 ft., and frequently a thin lava flow occurs within the thicker beds. The strike of these interbedded sediments is roughly east-north-east. parallel to the elongation of the lava plateau. On the north of the lava ridge they have a northerly, on the south a southerly, dip, and it therefore appears that the lavas are folded in an anticline. The intercalated sandstones, grits, and conglomerates indicate considerable interruption in the volcanic activity of the region. The thin flows intercalated among the grits and conglomerates at Bodinglee and Fallside farms (Fig. 7) show the gradual waning of the volcanic episode at this locality, but farther to the west-south-west the lavas transgress the strike of these sediments and in the area between Scaur Hill and Wedder Law it seems that there was a final outburst of volcanic activity contemporaneous with the formation of the higher conglomerates and grits at Bodinglee (half a mile west of Fallside). Between the thick belt of lava produced during this period and the main lava ridge, there is, three quarters of a mile east of Maidengill Farm, a thick intercalation of lava-conglomerate and ashy grit which is probably contemporaneous with the lower thick conglomerate at Bodinglee.

The sediments of the Old Red Sandstone consist in the eastern part of the area of basal greyish-green sandstone and grit, followed by lava-conglomerates and chocolate sandstone. In the western part the basal green grits are replaced by chocolate sandstone and the conglomerates die out. The great lava-conglomerate which is best developed in the ground to the east, surveyed by Dr. Read, thins out and interdigitates with the chocolate sandstone to the west. The pebbles of this conglomerate are mostly well rounded and consist of various lava types which can be matched from the lava area to the north.

The lavas are intruded by two or three compact red felsite dykes, the largest of which, about 30 ft. wide, crosses the Parkhall Burn 400 yds. below its junction with Cuff Burn. A large boss of quartz-porphyry builds Brown Hill, one mile east-south-east of Douglas, and a smaller one is exposed in two quarries at the south corner of Mainshill Wood. The actual contact of lava and porphyry is never seen but the exposures in the burn south of Brown Hill are sufficiently good to justify the inference that the contact is practically vertical.

Lower Carboniferous.—Mr. Phemister's revision of the Calciferous Sandstone lavas has been completed by the survey of a long narrow strip near the western margin of one-inch Sheet 23, extending from the Avon Water northwards to Ardochrig Hill, and of a small area south of the Avon and near the Muirkirk road. In the latter the lavas consist entirely

Digitized by Google

of porphyritic and non-porphyritic olivine-basalts, but in the former area include, in addition to basalts, a number of more acid, trachytic or trachybasaltic, flows. Exposures are not numerous but in the Brock Burn, which joins the Calder Water near East Browncastle, a good section shows ash, agglomerate and lava dipping off the small hill called the Law which has already been described as a boss of trachybasalt.[1] A very prominent feature in this area is the intrusive mass forming Loudon Hill, rising on the east in crags 250 ft. high. The rock of which it is composed is dark and very fine-grained in the main with a rather platy fracture, and on the eastern and southern margins of the hill resembles mugearite. At the summit, towards the centre of the intrusion, it is coarser and carries squarish phenocrysts of felspar. On the south-western slopes, where it appears to be somewhat shattered, it is threaded with veins and lenticles of pink syenite which contain many inclusions of the dark rock of the hill ranging in size from mere spots up to round balls 1 inch in diameter.

Mr. Ross reports that the fringe of Calciferous Sandstone sediments skirting the western edge of the Bankend coalfield between Burnside and the head of the Poniel Water, rests unconformably on Lower Old Red Sandstone strata. In the faulted inlier exposed in the Shiel Burn and Poniel Water just east of Bankend the sequence is approximately as follows :—(1) a lower group, about 150 ft. thick, of red flaggy sandstones with subordinate bands of red and green marl throughout, and thin cornstones near the base; (2) an upper group, about 200 ft. thick, of grey and yellow flaggy and false-bedded sandstones with intercalated gritty bands. The top of this section must be only a short distance below the *Productus giganteus* Limestone or Limestone C of Fig. 9 in last year's 'Summary of Progress' (*Mem. Geol. Surv.*, 1924, p. 108).

Mr. Phemister and Mr. Manson have re-examined the Limestone outlier at Wedder Law on the south margin of Sheet 23. The section exposed in the old quarries is as follows :—

	Ft.	in.
Limestone, nodular, with crinoids, etc. .. at least	4	0
Blaes, shelly at top	3	6
Limestone, massive, hard, blue; top 2 or 3 in. partly decalcified and yellowish-weathering	2	0
Blaes, with limy bands	7	0
Coal, slaty	0	1
Ganister, rooty	1	8
Sandstone, white, nodular and clayey, with *Stigmaria* ..	1	4
Sandstone	2	3
Limestone, nodular, rediish	0	3
Limestone, compact, blue, and limy blaes; with *Productus giganteus*, etc.; *Lithostrotion* in lower 3 ft.	10	0

The large *Productus* here is the less furrowed form found in the Main Limestone of Bankend and Coalburn (*cf.* 'Summary of Progress' for 1923, *Mem. Geol. Surv.*, 1924, pp. 109, 140) and the limestone

[1] 'Summary of Progress' for 1922 (*Mem. Geol. Surv.*), 1923, p. 88.

Digitized by Google

exposed at Wedder Law may be correlated with that seam. It rests unconformably on the sandstones and lava-conglomerate of the Lower Old Red. In the main quarry a small flat fault or thrust is seen at one point to duplicate the ganister and the limestone above it.

Half a mile north-west of Pagie Hill a very small patch of Carboniferous sediment is exposed in an old quarry. It consists of a hard white ganister-like sandstone, comparable, except in the absence of rootlets, to the ganister at Wedder Law.

Fairly good sections of the Main Limestone and associated strata are seen in the Ponfeigh Burn below Muirfoot. The limestone is about 18 ft. thick and overlies light-coloured clayey sandstones and fireclays. These take on a greenish tinge lower down and at a depth of approximately 25 fms. below the Main Limestone pass into chocolate-coloured sandstones and marls. About 15 fms. under the limestone occurs a thin band of shelly blaes, and this horizon, along with the greenish sandstones and marls, is again seen in the burn five to six hundred yards north-west of Chapel.

The small outlier of Carboniferous rocks resting upon the Lower Old Red Sandstone at Limefield, 1 mile west of Newton (Fig. 7), has been examined by Dr. H. H. Read. The sections are now much overgrown but the following table represents the most complete section now visible :—

	Ft.	in.
Yellow sandstone	—	
Limestone, grey, fine-grained, shelly, encrinital	1	6
Calcareous blaes with fossiliferous limestone nodules	1	0
Calcareous blaes	1	0
Coaly fireclay, sandy, plant fragments; marine fossils preserved in pyrites	0	7
Coal	0	1
Daugh	0	1
Sandstone, planty, with faky layers	3	11
Clay, grey, with limy balls	1	5
Ganister	1	5
Soft grey clay with limestone nodules	1	0
Limestone, cream-coloured, nodular, *Productus giganteus* common; irregular top	1	0
Limestone, full of *P. giganteus*, giving a nodular appearance: corals in top part	2	7
Limestone, grey, with *P. giganteus*	1	5
Calcareous blaes, with nodules of limestone, and layer of *Lithostrotion* at top	0	11
Limestone, in two nodular layers	1	4
Limestone, grey, encrinital, base not seen	2	8

The large *Productus* here is the true *Productus giganteus* (Mart.) of this district and its presence suggests the correlation of this limestone with the *P. giganteus* Limestone of Bankend.

Coal Measures.—The area of Coal Measures which stretches up the Douglas valley from near Happendon Bridge has been examined by Messrs. Ross and Phemister. Very few natural sections are available and distinctive horizons are rare. This coalfield, sharply

Digitized by Google

delimited by more or less parallel boundary faults, takes the form of a narrow basin elongated in a south-south-west direction. The strata dip steeply towards the centre of the basin and the total thickness of Carboniferous rocks must be very considerable. The Barren Red Group alone is represented by at least 200 fms. A good section of strata belonging to this group is exposed in the lower part of the Arnesalloch Burn.[1] Partial sections of the Productive Measures are also seen here and in the Glebe, Broadlea, and Windrow Burns. At all these localities 'musselbands' are recorded but it is not yet possible to assign these to definite horizons. The 'musselband' seen in the Broadlea Burn a short distance above Broadlea Cottage appears to occupy a position 8 to 10 fms. above the Seven-foot Coal. The Glebe Burn furnishes a fairly good section of the strata from above the Seven-foot to below the Nine-foot Coal. 'Musselbands' are found here a short distance above the latter and again about 18 fms. below it. Both of these have been noted in borings.

M. MACGREGOR.

[1] Flows past Townhead on the east side of the valley.

Digitized by Google

3. FIFE AND KINROSS

C. H. DINHAM, B.A., District Geologist.
D. HALDANE, B.Sc.,
J. K. ALLAN, M.A., B.Sc., } Geologists.
J. KNOX, B.Sc.

The revision of this coalfield was continued by Messrs. Haldane, Allan and Knox, Mr. Dinham being occupied throughout the year with the new edition of the special Glasgow memoir and with the completion of the survey of the Stirlingshire coalfield lying in one-inch Sheet 39, between Stirling and Plean. Mr. Haldane, in the district of Carnock and the Saline Hills, carried his previous work eastwards towards Dunfermline. Mr. Allan surveyed the country between Benarty Hill and Cardenden, and Mr. Knox the coastal belt from Kinghorn to Kirkcaldy.

It should be mentioned that Dr. Lee's examination of the cores of various borings in central Fife, undertaken at intervals during the past two decades, has already proved of the greatest value in the interpretation of other journals now being collected by the surveyors. In a district like Fife, where the easily recognisable Upper limestone seams of other areas are commonly represented merely by a layer of marine shells, the importance of core examination is even greater than in other fields of Limestone Coals; and Dr. Lee's work, prior to the general revision now in progress, has secured for the Survey stratigraphical information of great economic importance which would otherwise have been lost.

Calciferous Sandstone Series: Oil Shale Group.—Mr. Knox has re-surveyed the more or less continuous section of these strata which outcrops on the coast from Burntisland to Kinghorn, and has made a fresh examination of the plans of the oil shale workings east of the Binn. It now appears that the thickness of strata between the Dunnet Shale and the probable equivalent of the Fells Limestone, seen on the road opposite the old school at Binnend, is greater than was previously supposed, amounting to 350 ft. instead of 210.[1] About 75 to 100 ft. above the Fells Limestone the thin coal corresponding to the Houston Coal of the Lothians is almost immediately overlain by the lowest of the lava flows. Thus at this point there are over 400 ft. of sediments between the Dunnet Shale and the base of the lavas. Half a mile to the south-east, however, above Dodhead Quarry, the shale is within 200 ft. of the lavas, the lowest exposure of which is seen in the small cliff east of the quarry. This discrepancy of 200 ft. or more is susceptible of more than one explanation, and further evidence is required before it can be satisfactorily interpreted.

[1] 'Oil-Shales of the Lothians.' (*Mem. Geol. Surv.*), 1906, p. 97, and 1912 (2nd edition), p. 82.

Digitized by Google

What appears to be a new outcrop of limestone has been noticed in the field above the east end of King Alexander's Crag. This bed, at least 2 ft. thick, has a striking resemblance to the well-known plant-bearing limestone of Pettycur. It is dark-coloured and coarsely crystalline, with poorly preserved but unmistakable plant remains in the form of casts and impressions of stems and roots. It seems highly probable, however, that this limestone, if continuous for any distance, lies above the lava-flow which in the past has been found to contain blocks of the Pettycur Limestone, and therefore it cannot well be regarded as having given origin to these blocks. It is more probably on or close to the horizon of the lithologically dissimilar freshwater(?) limestone seen at the entrance to the cutting at the west end of the Kinghorn railway tunnel.

Carboniferous Limestone Series : Lower Limestones.—In the ground west of Dunfermline and the Roscobie Hills, Mr. Haldane has made considerable advances on the older maps in point of detail. Boring information is, however, so scarce, the drift cover locally so thick, and the exposures of the limestones and associated strata so overgrown that the structure cannot yet be completely elucidated ; it appears, however, likely to be still more complex than has been hitherto supposed.

This group of strata is well displayed on the foreshore opposite Seafield Tower, south of Kirkcaldy, and has been carefully measured by Mr. Knox. The details of the portion of the sequence above the Seafield Tower Limestone are now for the first time given, in Fig. 8. Correlation of this section with the succession established for the Dunfermline district and given in the 'Summary of Progress' for last year, cannot yet be made with confidence ; but in the meantime all indications point to the equivalence of the First Abden with the Charlestown Station Limestone, and hence with the Hurlet Limestone of Hurlet in the West of Scotland—a view advocated by Professor P. Macnair.[1] It also appears likely that the Seafield Tower Limestone will prove to be on the same horizon as the Main Limestone of Charlestown, the Blackhall Limestone of the Glasgow district, and the Gilmerton Limestone of Midlothian.

With reference to the 'bone-bed' below the First Abden Limestone, it may be noted that, in the description of the coast section in the memoir,[2] the dark shales with the 'bone-bed' near their base are indicated as lying directly upon a lava, while above them is a pale marly shale or fireclay. These particular beds were perhaps measured at a small exposure above high-water mark, now covered with fallen debris ; at present they can only be examined between tide marks, where the marly shale was found by Mr. Knox to occur below the 'bone-bed' and to separate it from the lava.[3]

[1] 'The Hurlet Sequence in the East of Scotland. . . . ,' *Proc. Roy. Soc. Edin.*, vol. xxxvii, pt. ii, 1917, p. 194.

[2] 'Geology of Central and Western Fife and Kinross-shire' (*Mem. Geol. Surv.*), 1900, p. 72.

[3] *cf.* P. Macnair, *loc. cit.*

Digitized by Google

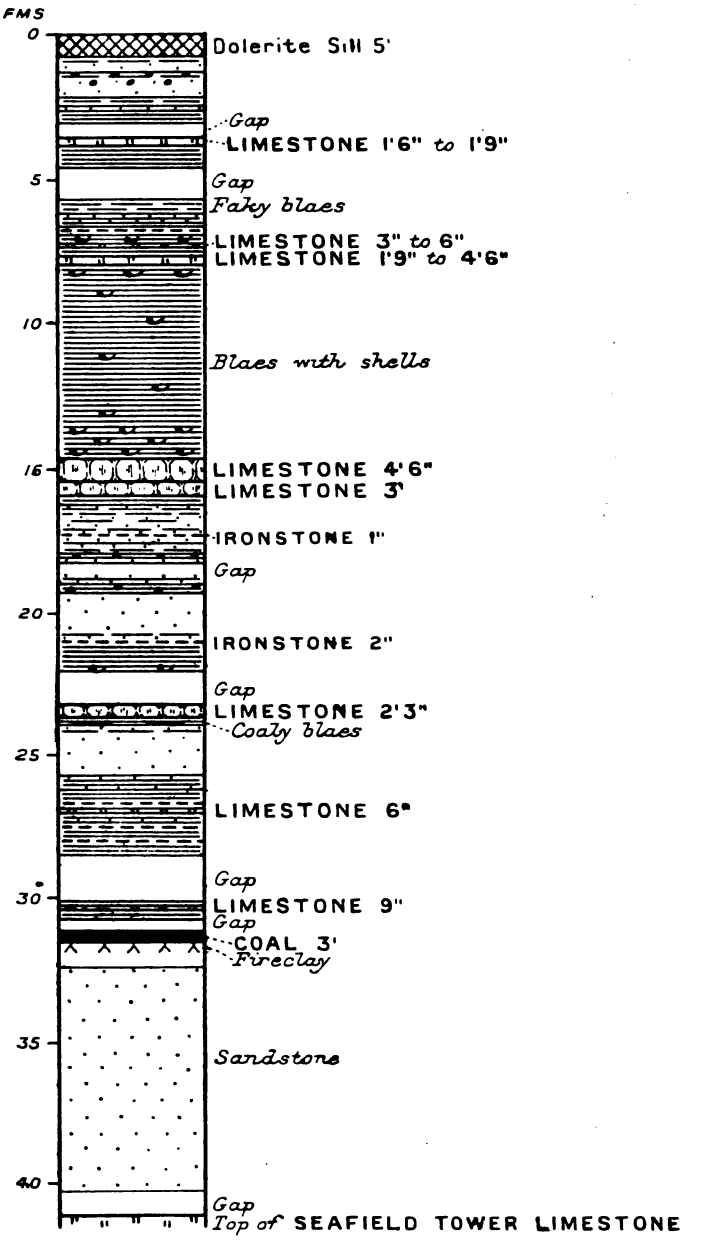

FIG. 8.—*Section of Hosie Limestones on the shore opposite Seafield Tower, Kirkcaldy.*

Digitized by Google

An exposure of marine limestone, previously unrecorded, has been discovered by Mr. Knox in the cutting of the mineral railway line from Invertiel to Auchtertool, about 500 yds. west of Invertiel Farm. Of the 20 inches which are visible, the upper half is pale, crystalline and indurated by overlying igneous rock; the lower half is dark with fairly abundant encrinites, a few cup corals and brachiopods, including a giganteid *Productus*. With regard to the horizon of this bed, nothing definite can be stated as yet; it is certainly below the Seafield Tower Limestone, and may be on or about the horizon of the First Abden.

The limestone formerly quarried at Invertiel, 1 mile north-west of Seafield Tower, had previously been mapped as a continuation of the Second Abden Limestone, but it was also suggested in the memoir that it might be the 'Hurlet' [Seafield Tower] seam, and this view, also held by Professor Macnair, is probably correct. Mr. James Wright of Kirkcaldy, who has made a very careful study of the limestones in this district, has always been of this opinion.[1]

In the Seafield section (Fig. 8) all the limestones above the Seafield Tower Limestone resemble one another in being impure, and their lower portions are merely limy sandstones. The topmost limestone contains encrinites up to half an inch in diameter, and a few cup corals of Zaphrentid type. Small crinoid stems are found in the two limestones at 7½ fms., the lower of which contains also a few small cup corals, sponges in section, fragments of shells, and *cauda-galli* impressions. Only a few fragments of shells were noted in the mass of blaes below, except in the upper 3 or 4 ft., which show small encrinites, turreted gastropods, and lamellibranchs, and in the lower 4 or 5 ft., which are abundantly fossiliferous, the organic remains being in general similar to, but smaller than, those found in the upper part of the underlying limestone. This limestone, at 15 fms., consists of an upper dark shaly portion, abundantly fossiliferous, and a lower brownish portion, relatively barren except in the bottom 2 or 3 ins., which are again shaly. The fossils in the upper post include large encrinites, large and small cup corals, brachiopods and lamellibranchs. An interesting characteristic of this limestone is the manner in which it is cut by reversed faults which rapidly disappear when traced into the adjoining strata. Similar fossils are again found in 'nests' on the upper surface of the limestone at 23½ fms., which contains large calcareous nodules. Only small crinoid stems are seen in the limestone at 27 fms. which is characterised by unusually irregular weathering. The lowest limestone, at 30½ fms., is somewhat lenticular with encrinites and shell fragments; gastropods occur in addition in the overlying shales. Between this bed and the massive false-bedded sandstone on which stands Seafield Tower there is a gap in which Mr. Wright has observed a 3 ft. coal resting on fireclay.

In a bore put down by the Fife Coal Co. about 1,000 yds. north

[1] 'Geology of Central and Western Fife,' *op. cit.*, pp. 90, 91; P. Macnair, *loc. cit.*; J. Wright, 'On the Crinoids from . . . Invertiel, Fife,' *Trans. Geol. Soc. Edin.*, vol. x, pt. i, 1912, p. 59.

Digitized by Google

of Seafield Tower, the sequence found was similar to the above, but the 2 ft. 3 in. limestone at 23 fms. in the figure is only an 8 in. 'limestone fake' in the bore. The massive Seafield Tower sandstone has also in the bore been replaced by an equal thickness of fakes and blaes—strata more like those usually found above the Charlestown Main Limestone with which, as mentioned above, the Seafield Tower Limestone is probably to be correlated.

Carboniferous Limestone Series : Limestone Coal Group.—These strata occupy a large part of Mr. Haldane's ground, where they are disposed in two irregular belts, one running north-north-east from Valleyfield and Torryburn to Saline and Steelend, the other stretching at right angles to this towards Dunfermline. Considerable progress has been made in the determination of the sequence, but the irregularity of the coals, the multiplication of local names and the variations in the thickness of the strata introduce many difficulties. The group attains its maximum thickness, about 245 fms., near Blairhall, but thins out somewhat both northwards and southwards. To the east, the thinning is still more noticeable, the total distance between the Index and the Top Hosie Limestones amounting only to 195 fms. near the old Elgin Collieries, Dunfermline. More than half of this reduction of thickness takes place in one part of the sequence, between the Lochgelly Splint Coal and the Comrie Main (Ell, Duddie Davie, or Kinglassie Splint).

In the Lochgelly district Mr. Allan finds that the structure of the ground is of the general type shown on the old map, but that considerable alteration has to be made in the position of the faults and anticlines, which are also much more numerous than was formerly believed. The dominant trend of faulting is west-north-west, at right angles to the folding. One of the most important dislocations runs westwards near the northern margin of Loch Gelly throwing the strata up to the south, so that the Lower Limestones are near the surface and no workable coals will be found beneath or south-west of the loch. To the west of Lochgelly, in the main syncline, the coals lie at a considerable depth ; Mr. Allan has gathered much new information about this district and finds that the individual seams can be satisfactorily correlated with those of the Cowdenbeath area, detailed in last year's Summary.

South of Kirkcaldy several bores and mines sections have been obtained by Mr. Knox, which will enable the outcrops of the coals to be traced with some accuracy over this part of the field. The Limestone Coal Group appears to be considerably thinner here than it is further west.

Carboniferous Limestone Series : Upper Limestone Group.—In the west of the area, the sequence given in Fig. 12 of last year's Summary is maintained with fair constancy throughout the ground surveyed by Mr. Haldane. This diagram showed that there are four limy horizons between the Index and the Jenny Pate limestones, and indicated the supposed Fifeshire equivalents of the Orchard

Digitized by Google

and Lyoncross seams; but the evidence for these correlations with the Central Coalfield succession, which are carried from the Airth district of Stirlingshire, is none too strong, and it may become necessary to adopt a new nomenclature for these marine horizons in Fifeshire until opportunity is offered of examining the cores of some bore situated in the intervening territory.

This necessity is likely to be still more urgent in those more central parts of Fife which are separated from the Culross area by a tract, some 10 or 12 miles broad, in which all limestones higher than the Index have been removed by erosion. When the Upper Limestone Group reappears, near Capledrae north of Lochgelly, it seems to have undergone considerable reduction in thickness and in the number of marine horizons; and since the *Edmondia punctatella* band, which characterises the Jenny Pate or Calmy Limestone in western areas, has not yet been detected in the central or eastern portion of the county (though a special search was made by Mr. Haldane and Mr. Knox in the coast section east of Pathhead, Kirkcaldy) definite correlations with the Central Coalfield possess as yet no very certain basis. Nevertheless the customary identification of the Capledrae with the Jenny Pate or Hirst Coal of West Fife and Stirlingshire may well be correct, for reasons indicated in the next paragraph; but the correlation of any lower marine horizon with the Orchard and Lyoncross Limestones of the Central Coalfield is not justifiable in the present state of our information.

Mr. Allan finds that the thickness of the Upper Limestone Group in his district varies from about 130 to 155 fms. of sediment, together with 50 to 80 fms. of dolerite intrusions. The Index position appears nowhere to be marked by a good limestone, as it sometimes is marked in the west of the county; in one bore on Pitkinny it seems to be reduced to a layer of Orthotetid shells in shale. Thirty-five fathoms higher, just above the Lochore Parrot and Ironstone, a thick shale is very constantly found which in the South Pitkinny bore yielded an obscure lamellibranch (*Anthracomya?*). This horizon may perhaps correspond to the equally constant limy shelly blaes overlying Cadell's Parrot in Mr. Haldane's ground. About 75 to 80 fms. (neglecting intrusions) above the position of the Index lies the Capledrae Parrot Coal, in the roof of which is a fissile parrot rib. Though barren, this rib was pronounced by Dr. Lee, when met with in a bore on South Pitkinny, to be lithologically similar to the somewhat peculiar sediment with which *Edmondia punctatella* is habitually associated in the west; and 2 to 7 fms. above it, in a considerable thickness of blaes, marine fossils were found at intervals, with a 2-in. limestone rib. It would thus appear that this marine horizon, which we may provisionally call the Capledrae Marine Bed, is quite probably equivalent to the Jenny Pate, Gair or Calmy Limestone. It follows that the Kirkness Limestone, which is separated from the Capledrae Coal below it by some 60 fms. of sediment, is more likely to correspond to the Levenseat (Castlecary) than to the Gair—a point undecided at the

Digitized by Google

time of writing the memoir.[1] Unlike the other marine horizons of the group, the Kirkness Limestone, averaging 3 to 3½ ft., is thick enough to have been quarried at one time. In a bore on Pitkinny the main portion of the Kirkness Limestone was found to be pale and crystalline (a characteristic of the Levenseat in the west of the county) with occasional dark streaks.

Igneous Rocks.—In the Saline district, Mr. Haldane has found that little can at present be added to the description of the old volcanoes contained in the memoir.[2] The principal additions point to a great multiplication of the faults dislocating the mass, and the discovery that the summit of Knock Hill consists of a large basaltic mass, probably in the nature of a plug in the ash neck similar to that which occurs in the Saline Hill, 1 mile to west-south-west. The volcanic activity certainly began before the deposition of the Index Limestone, and probably continued to a considerably higher horizon; it is, however, doubtful whether in this district it lasted as late as the Jenny Pate Limestone.

Interesting evidence bearing on the date of the volcanic activity in another part of Fife has been obtained in Mr. Allan's ground at Lochore. At the horizon of the Little Splint Coal the workings have disclosed the existence of a neck, filled with fairly coarse agglomerate which contains angular fragments of limy basalt in a dark matrix of granular quartz and fine argillaceous material. At the margins of this vent, which has been penetrated for a distance of 60 yds., the strata dip sharply towards its centre, and have been much broken and pierced by veins and dykes of bleached trap. But at the surface of the ground no trace of the agglomerate can be detected, and indeed the workings of the Capledrae Parrot Coal extend over the site of the vent without interruption. Activity must therefore have ceased at least before this coal was deposited. But its date can perhaps be fixed within still narrower limits; for a limy ash, recorded in bores to the east at the horizon of the Lochore Parrot Coal, in all probability originated in this vent. In these bores, and in the Mary Pit, Lochore, a whinstone is found in association with the ash and may prove to be a lava flow.

Dolerite intrusions, frequently of great thickness, occur abundantly throughout these parts of Fife, many of them being shown as irregular masses on the existing map; but it is hoped that it will be possible, with the aid of boring records, to join up the outcrops in a manner which will more clearly exhibit the fact that they form part of a relatively small number of sills, which are continuous right through the district. The task will be one of considerable difficulty, as the intrusions rarely maintain a constant horizon for any distance.

---

[1] 'Geology of Central and Western Fife' (*Mem. Geol. Surv.*), 1900, p. 138.
[2] 'Geology of Central and Western Fife' (*Mem. Geol. Surv.*), 1900, p. 128.

Digitized by Google

The area surveyed by Mr. Knox is largely occupied by lavas as well as intrusions, and it is often by no means easy to distinguish the one from the other. In a recent paper by Dr. D. A. Allan[1] evidence is put forward to show that several of the masses previously mapped as lavas are more probably intrusive. Comment on these rocks will be reserved until the survey of the whole of this igneous tract has been completed.

C. H. DINHAM.

[1] 'The Igneous Geology of the Burntisland District,' *Trans. Roy. Soc. Edin.*, vol. liii, pt. iii, 1924, pp. 479–501 and plates.

Digitized by Google

III.—PETROGRAPHICAL WORK

1. England and Wales

Material of petrographical interest collected in the course of field-work by the various field-staffs continues to arrive, and although of no special outstanding importance will form the basis for useful petrographical additions to the respective sheet memoirs as published. Material has been sent in for examination from the Lake District, the western Midlands, and Northumberland, where field-work is now in progress.

2. Scotland

Dr. Thomas and Mr. Richey have been concerned mainly with the petrography of Ardnamurchan (Sheets 51 and 52) while Dr. Thomas and Mr. Bailey with Mr. Anderson have completed the petrographical work connected with the Ross of Mull, Iona, Coll and Tiree.

Dr. Read has completed his petrographical work in the Banff, Turriff and Huntly Districts and Mr. Phemister has written a petrographical account of the alkali-rocks of Sutherlandshire (Sheet 102).

Mr. MacGregor has made good progress with the petrographical work connected with the igneous rocks of Ayrshire (Sheet 22) the results of which will be published in the forthcoming memoir.

Herbert H. Thomas.

Digitized by Google

IV.—CHEMICAL WORK

The Chemical Department, in 1924, has completed quantitative analyses of fifty-four rocks, and examined qualitatively twenty-five mineral samples. Eleven of the analyses—Lab. Nos. 743, 744, 746, 747, 751, 753, 757, 758, 759, 760 and 787, are published in the Special Report on Mineral Resources, Vol. XXIX.—Iron Ores, and Lab. Nos. 761 to 765 inclusive are intended for the Sheet 22 Memoir (Ayrshire). Ten of the remainder are selected as being sufficiently noteworthy for publication in this report.

729. *Igneous Knob in Moine Schists.*—500 yds. W.S.W. of Ach'uaine, which is 3 m. E. 10° S. of Invershin Station, Sutherlandshire. 1-in. map, 102; 6-in., Sutherland, 108 S.W. Sl. No. S21423. The rock is near the starting point of a Scyelite-Granite series of hybrids (Summary of Progress, 1920, pp. 46 and 47).

730. *Igneous Knob in Moine Schists.*—Summit of Cnoc a' Choire Bhuidhe, 1300 yds. W.N.W. of Ach'uaine. 1-in., 102; 6-in., Sutherland, 108 N.W. Sl. No. S21424. A somewhat basic hybrid of the Scyelite-Granite series of Ach'uaine (Summary of Progress, 1920, pp. 46 and 47).

731. *Igneous Knob in Moine Schists.*—Near summit of Cnoc a' Choire Bhuidhe, 1600 yds. W. 15° N. of Ach'uaine. 1-in., 102; 6-in., Sutherland, 108 N.W. Sl. No. S21425. An acid member of the Scyelite-Granite series (Summary of Progress, 1920, pp. 46 and 47).

768. *Massive coarse-grained Syenite outcropping beneath fine-grained Syenite (Perthosite).*—East face of Creag na Fearna, 1000 yds. W. 37° N. of junction of R. Oykell and Allt Sail an Ruathair. 1-in., 102; 6-in., Ross, 2*b*. Sl. No. S22056. A type of Riebeckite-syenite.

769. *Massive Ultrabasic Rock pierced by Syenite veins.*—Bed of Allt Cathair Bàna (Allt Cathraichean Bàna). 520 yds. from junction with R. Oykell. 1-in., 102; 6-in., Sutherland, 92 N.W. Sl. No. S22070. A type of the most ultrabasic part of the Loch Ailsh laccolite.

770. *Massive Syenite building S. peak of Sail an Ruathair.* 590 yds. W.S.W. of Loch Sail an Ruathair. 1-in., 102; 6-in., Sutherland, 83 S.W. Sl. No. S23160. Type of Aegirine-melanite-syenite.

Lab. No. ..	729.	730.	731.	768.	769.	770.
SiO_2	37·78	53·25	57·28	62·01	40·73	64·89
TiO_2	1·93	1·26	0·85	0·74	2·86	0·30
ZrO_2	—	—	—	0·05	—	—
Al_2O_3	11·83	14·20	15·75	16·26	6·29	14·97
Fe_2O_3	2·46	2·94	2·37	2·24	10·29	5·28
Cr_2O_3	0·19	trace	—	nt. fd.	nt. fd.	nt. fd.
V_2O_3	0·02	—	—	nt. fd.	nt. fd.	nt. fd.
FeO	4·34	3·60	2·14	1·09	8·89	0·71
MnO	0·41	0·31	0·20	0·36	0·41	0·27
(Co,Ni)O ..	nt. fd.	nt. fd.	nt. fd.	nt. fd.	nt. fd.	nt. fd.
BaO	nt. fd.	nt. fd.	nt. fd.	0·03	0·01	0·04
CaO	15·31	7·44	5·48	2·99	14·82	1·00
MgO	11·22	5·40	3·38	0·82	12·17	0·38
K_2O	4·29	5·00	5·04	4·75	2·25	4·70
Na_2O	0·62	3·20	3·87	6·47	0·87	7·27
Li_2O	nt. fd.	nt. fd.	nt. fd.	trace	nt. fd.	nt. fd.
H_2O at 105° C.	0·15	0·16	0·06	0·05	0·04	0·07
H_2O above 105° C.	1·24	0·88	0·93	0·31	0·43	0·25

Digitized by Google

Lab. No. ..	729.	730.	731.	768.	769.	770.
P_2O_5	0·53	0·52	0·52	0·19	0·19	0·10
FeS_2	0·10	0·04	nt. fd.	0·01	nt. fd.	0·02
Fe_7S_8	nt. fd.	nt. fd.	nt. fd.	nt. fd.	nt. fd.	nt. fd.
SO_3	—	—	—	nt. fd.	—	—
CO_2	7·80	2·01	2·32	1·68	0·17	0·04
F	—	—	—	nt. fd.	nt. fd.	0·01
Cl	—	—	—	0·01	trace	nt. fd.
TOTALS ..	100·22	100·21	100·19	100·06	100·42	100·30

Analysed by E. G. RADLEY.

737. *Quartz Dolerite, Intrusive Mass in Volcanic Vent.*—In cliffs 700 ft. above Camas na Cloiche Moire, Beinn Hiant, Ardnamurchan, Argyll. 1-in., 52; 6-in., Argyll, 25 S.W. Sl. No. S21253 (Summary of Progress, 1923, p. 128).

738. *Olivine Dolerite, Intrusive Mass in Volcanic Vent.*—In stream bank, 705 yds. S. 19° E. of Beinn Hiant Cairn and ½ m. W. 24° N. of Bourblaige, Ardnamurchan. 1-in., 52; 6-in., Argyll, 25 S.W. Sl. No. S21254 (Summary of Progress, 1923, p. 128).

739. *Pitchstone Lava, Sheet interbedded with Agglomerate in Volcanic Vent.*—In stream bank, 1145 yds. S. 12° E. of Beinn Hiant Cairn and ½ m. W. 3° S. of Bourblaige. 1-in., 52; 6-in., Argyll, 25 S.W. Sl. No. S21255 (Summary of Progress, 1923, p. 128).

741. *Fireclay. Bed resting on Sandstone Horizon: Millstone Grit immediately below Millstone Grit Volcanics.* By S. side of fence 200 yds. W. 19° S. of Gardrum, Fenwick, Ayrshire. 1-in., 22; 6-in., Ayrshire, 13 S.W. (N.S.).

Lab. No.	737.	738.	739.	741.
SiO_2	50·67	49·60	66·06	44·81
TiO_2	2·88	2·38	1·08	1·25
Al_2O_3	11·89	15·06	13·14	38·03
Fe_2O_3	8·61	5·29	2·27	0·58
Cr_2O_3	trace	0·02	trace	trace
FeO	7·08	5·00	2·84	0·11
MnO	0·20	0·19	0·31	0·08
(Co,Ni)O	nt. fd.	nt. fd.	nt. fd.	nt. fd.
BaO	0·02	trace	trace	trace
CaO	7·75	9·69	2·75	0·12
MgO	3·94	4·44	0·77	0·07
K_2O	1·50	0·70	1·54	0·02
Na_2O	2·94	2·62	4·28	0·12
Li_2O	nt. fd.	trace	trace	trace
H_2O at 105° C.	1·05	2·65	0·74	1·15
H_2O above 105° C. ..	0·77	1·29	3·38	13·30
P_2O_5	0·55	0·29	0·09	0·04
FeS_2	0·02	nt. fd.	trace	nt. fd.
SO_3	0·38	0·40	0·16	0·21
Org. Matter	0·01	trace	0·02	0·03
CO_2	0·21	0·44	0·37	0·29
TOTALS	100·47	100·06	99·80	100·21

Analysed by B. E. DIXON.

Digitized by Google

Sixteen hornblendic and serpentinous samples from the Lewisian Gneiss in the vicinity of Stornoway were carefully assayed by several methods for tin. Some residues obtained in one method (by evaporating the opened-up rock with nitric acid) were the only obtainable suggestions of the existence of the metal, but spectrophotographic examination of these residues by ultra-violet light definitely negatived this evidence.

In connexion with the work for the Special Report, Vol. XXIX, Iron Ores, an electrometric method for the determination, in alkaline solution, of acid-soluble ferrous iron was developed. An investigation into the method of estimating ferrous iron in silicate rocks showed a possibility of attaining distinctly more satisfactory results by the adoption of J. F. Pratt's method as modified by W. F. Hillebrand; and the unsatisfactory nature of the processes for the determination of the various forms of mineral sulphur compounds has prompted some further research; these pieces of work are yet in their initial stages.

R. SUTCLIFFE.

Digitized by Google

V.—PALÆONTOLOGICAL WORK

In London

F. L. KITCHIN, Sc.D., Ph.D., Palæontologist (District Geologist).
J. PRINGLE, Assistant-Palæontologist (Senior Geologist).
C. P. CHATWIN, Assistant-Palæontologist (Geologist).

In Edinburgh

G. W. LEE, D.Sc., Senior Geologist.

I. ENGLAND AND WALES

Parts 5 and 6 of the late Dr. Kidston's memoir on the Carboniferous plants of Great Britain have been prepared for the press and will shortly be published. Other palæontological memoirs are also in course of preparation. Prof. O. T. Jones has made a prolonged study of the genus *Plectambonites* and its allies, from the Ordovician and Silurian rocks of this country. His memoir on this subject, now almost ready for printing, embodies results which will prove of much value in stratigraphical work. Miss H. M. Muir-Wood has continued the study of the Carboniferous *Producti*, begun some years ago by the late Dr. Ivor Thomas. Her first contribution to this subject, which has been completed, deals with the genus *Productus* as now restricted. This memoir is well advanced in its preparation for the press.

With the publication of Part 6 of Dr. Kidston's work the second volume of the palæontological series of Memoirs will be completed. The continuation of this monograph at some future date will be included in another volume of the series. The first volume of these palæontological Memoirs will be completed by the publication of Miss Muir-Wood's contribution as its last part. It is proposed to issue Prof. Jones's work as the first part of the third volume of the series.

Dr. Kitchin and Mr. Pringle made an examination of a collection of Kimmeridge and Portland ammonites from localities in Oxfordshire, preserved in the University Museum, Oxford. Many of the specimens proved to belong to undescribed genera and species. The collection includes ammonites from the sandy development of the Kimmeridge beds at Shotover and Wheatley, formerly confused with the Portland Sands of the Dorset coast. The specimens seen give further support to the correlation of these sands with the Cemetery Beds at Swindon.

Digitized by Google

Mr. Pringle has spent three months in Oxfordshire, studying sections in connexion with the preparation of a new edition of the memoir on the special Oxford sheet. He has completed his examination of the Lower Oolites and the Cretaceous rocks comprised within the area.

During visits to certain areas just to the north of the special Oxford sheet, Mr. Pringle collected specimens of *Epithyris marmorea* (Oppel) in the Forest Marble, a shell hitherto unrecorded from Oxfordshire. He finds that this species is confined to the local basement-bed of the formation. The discovery of this brachiopod proves that Phillips was right in originally assigning the clay beds containing *Cetiosaurus oxoniensis* Phillips to the Forest Marble. *Epithyris marmorea* has also been found in similar green and dark clays of the Forest Marble in Kent and in the Boulonnais. Within the area of the special Oxford sheet, these Marmorea Beds are absent owing to a marked unconformity at the base of the formation.

Among the numerous deep borings visited by Mr. Pringle during the year, two are of special interest. At Marsh Hill Farm, near Aylesbury, a boring made in search for water proved the absence of the 'Lower Greensand' and the Portland and Purbeck rocks, although these crop out to the north less than a mile from the boring. The Gault was found to rest directly on the Kimmeridge Clay. At Fobbing, in Essex, a boring for water showed that the Gault, with a conglomeratic basement-bed, there rests on rocks of Cambrian age. An account of this boring will be found in Appendix I (p. 132).

An exhibit of fossils was arranged by Mr. Chatwin and Mr. Hester at the British Empire Exhibition at Wembley. The specimens were selected to illustrate some of the applications of palæontology in geological mapping and economic work, and the principles were fully explained by labels and diagrams.

The large and valuable collection of fossil plants bequeathed to the Geological Survey by the late Dr. Robert Kidston forms a notable acquisition. It includes some hundreds of types and figured fossils, and is otherwise remarkable for the generally fine quality of the specimens. The collection will prove invaluable to all who are engaged in the study of Carboniferous plants and the geology of the coalfields. Another valuable addition to the collections during the year was the extensive set of specimens obtained by Mr. W. H. Dyson during the sinking of the Maltby Colliery shafts, near Doncaster. These fossils, for the most part molluscs and brachiopods, were carefully collected and recorded by Mr. Dyson, who has also furnished a detailed section with full particulars of all the palæontological horizons passed through. The collection will be of great use during the investigations now proceeding in the Yorkshire coalfield.

The following specimens in the Museum have been figured described or mentioned in publications :—

Digitized by Google

In the Palæontographical Society's Volume for the Year 1921.

(Published 1924.)

The Pliocene Mollusca of Great Britain, Volume ii.

By the late Mr. F. W. Harmer, M.A., F.G.S., F.R.Met.S.

Trochus (Calliostoma) millegranus (*Philippi*), pl. lviii, fig. 10 (2 views), p. 719.
,, ,, multigranus (*S. V. Wood*), pl. lviii, fig. 13 (2 views), p. 720.
Turbo (Senectus) newtoni (*A. Bell*), pl. lix, fig. 23 (2 views), p. 706.
Velutina virgata *S. V. Wood*, pl. lx, fig. 27 (2 views), p. 761.
Capulus venustus *Harmer*, pl. lxi, fig. 8 (2 views), p. 766.
Brocchia plicata *Harmer*, pl. lxi, fig. 11 (2 views), p. 769.
,, partim-sinuosa (*S. V. Wood*), pl. lxi, fig. 12 (2 views), p. 769.
Odostomia plicata (*Montagu*), pl. lxiv, fig. 18 (2 views), p. 837.

A Monograph of the Ammonoidea of the Gault.

By Dr. L. F. Spath, F.G.S.

Pictetia astieriana (*d'Orb.*), pl. i, figs. 7a, b, p. 27 (3 specimens).
Beudanticeras beudanti (*Brongn.*), pl. ii, figs. 4c, d, p. 49 (4 specimens).
,, laevigatum (*J. de C. Sow.*), pl. iii, figs. 2a–c; text-figs. 13c, d, p. 55 (7 specimens).
,, ligatum (*Newton & Jukes-Browne*), pl. iii, figs. 3c, d, p. 58 (5 specimens).
,, dupinianum (*d'Orb.*), pl. iv, figs. 1a–d, p. 60 (4 specimens).
Cleoniceras ? devisense *Spath*, pl. iv, figs. 7a, b.
Phylloceras subalpinum (*d'Orb.*), p. 15 (3 specimens).
,, seresitense *Pervinquière*, p. 18.
Puzosia mayoriana (*d'Orb.*), p. 42 (2 specimens).
,, sharpei *Spath*, p. 46 (3 specimens).
,, communis *Spath*, p. 47 (2 specimens).
Douvilleiceras mammillatum (*Schloth.*), emend., p. 68 (9 specimens).

In the Quarterly Journal of the Geological Society, Volume LXXX.

On a recently discovered Breccia-Bed underlying Nechells (Birmingham), and its relations to the Red Rocks of the District.

By Prof. W. S. Boulton, D.Sc., F.G.S.

Appendix.—The Cambrian Fossils from the Breccia-material in the cores of the boring at Nechells Gas-Works, Birmingham (embodying the Identifications and Notes made by

Mr. E. S. Cobbold, F.G.S.).

Micromitra phillipsi *Holl*, p. 366 (5 specimens).
,, (?), p. 366.
Acrotreta, p. 366.
Hyolithellus (?) sinuosus (?) *Cobbold*, p. 366.
Coleoloides typicalis *Walcott, var.* multistriata *Cobbold*, p. 366 (2 specimens).
Salterella curvata *Shaler & Foerste*, p. 366.
Gen. nov. (possibly allied to Helcionella), p. 369.

Digitized by Google

Upper Viséan Corals of the Genus Caninia.

By Mr. H. P. Lewis, B.A., F.G.S.

Caninia juddi (*Thomson*), pl. xxvii, fig. 1, p. 391.
,, ,, *var.* cambrensis *Lewis*, p. 397.

Descriptions of Gasteropoda, chiefly in Mrs. Robert Gray's Collection, from the Ordovician and Lower Silurian of Girvan.

By Mrs. Jane Longstaff, F.L.S., F.G.S.

Liospira disciformis *Longstaff*, p. 411 (2 specimens).
,, striatula *Longstaff*, pl. xxxi, figs. 4a–c, p. 411.
Clathrospira trochiformis (*Portl.*), pl. xxxii, fig. 11, p. 415.
Eccyliomphalus bucklandi *Portl.*, pl. xxxviii, figs. 1a, b, 2a, b, p. 433 (2 specimens).
,, minor *Portl.*, pl. xxxviii, fig. 3, p. 433.
Liospira aequalis (*Salt.*), p. 413.
,, lenticularis (*J. Sow.*), p. 414.

In Type Ammonites, Volume V.

By Mr. S. S. Buckman, F.G.S.

Scaphitodites navicula *S. Buckm.*, pl. cdlix, figs. 1, 1a, b, 2.
Chamoussetia lenticularis (*Phill.*), pl. cdlxii, figs. 1, 2.
Prionodoceras excentricum *S. Buckm.*, pl. cdlxiv, figs. 1, 2.
Oxycerites waterhousei (*Morris and Lycett*), pl. cdlxxvi, figs. 1, 1a–c, 2.
Spinikosmokeras acutistriatum (*Robson*), pl. cdlxxxviB.
,, pollux (*Reinecke*), pl. cdlxxxvii.
Hoplikosmokeras hoplistes *S. Buckm.*, pl. cdlxxxviii.
,, fibuliferum *S. Buckm.*, pl. cdlxxxix.
,, phaeinum *S. Buckm.*, pl. cdxc.
Proplanulites fracidus *S. Buckm.*, pl. dvii.
Pictonia densicostata *S. Buckm.* [*Salfeld MS.*], pl. dxxxiii, figs. 1, 2.

In the Memoirs of the Geological Survey, England and Wales.

The Geology of the Country around Dartford (Chapter IV).

By Mr. C. P. Chatwin, F.G.S.

Micraster corbovis *Forbes*, pl. ii, figs. 1, 2, 6, p. 18.
,, praecursor *Rowe*, pl. ii, figs. 3, 7–9 (3 specimens).
,, coranguinum (*Leske*), pl. ii, figs. 4, 5, 10 (2 specimens).

2. Scotland

Dr. Lee reports that the palæontological work carried on in connexion with the revision of the Scottish coalfields has continued to prove of use in stratigraphical correlations for mapping purposes, and in estimating the probable horizons reached in borings.

Additional material was collected in order to ascertain how far the sequence apparently obtaining in members of the *Productus giganteus* group could be applicable outside of the Douglas district,

Digitized by Google

where such a possibility seems to exist, as suggested in the ' Summary of Progress ' for 1922. The new evidence still favours the view that the typical, fully furrowed *P. giganteus* can be regarded as characteristic of the ' *P. giganteus* ' Limestone, while a less furrowed form replaces it in the succeeding limestone. Representatives of the latter were obtained by Mr. Manson from the Broadstone Limestone of the Kilbirnie district, North Ayrshire.

General similarity of faunal facies, together with the presence of an unusual form, has given palæontological confirmation to Mr. Richey's reading of a difficult sequence in Ayrshire. A limestone in the Galston district had been correlated by him with the ' Top Hosie,' from its relations to the overlying ' Johnstone Shell-bed.' In a section near Cessnock Castle the same limestone was expected to occur, but there the ' Johnstone Shell-bed ' had not been located, so that the correlation was not as fully confirmed as desired. The fossil alluded to as being common to both localities is *Aulacorhynchus davidsoni* Barrois [*Chonetes concentrica ?* Dav., *non* de Kon.]. This form is extremely rare in Scotland ; until found in Ayrshire by Mr. Manson it was only known from a single locality in Kinross.

Messrs. Richey and Manson have succeeded in tracing Prof. Macnair's ' Hurlet Fauna ' farther south-west within North Ayrshire. Representatives of this fauna, including the typical *Sanguinolites abdenensis* Eth., were found at the base of the Dockra Limestone, in the right bank of the Rye Water, near Cunningham Baidland, Dalry.

One horizon in a boring of difficult interpretation, near Douglas, was recognized from the presence of a crowded layer of poorly preserved ?*Ambocoelia urei* (Flem.), matching closely a similar band found in the Upper Limestones of a field-section some distance away.

A find of palæontological interest worth recording here was made by Mr. Manson in the Upper Limestones of Garpel Water, near Springhill, Muirkirk. It consists of two specimens of the little-known bryozoan *Ramipora* Toula, a genus originally described from the Upper Carboniferous Rocks of Spitzbergen and subsequently found only in Grinnell Land (Arctic America), in the Caradoc of Wales, and in the English Devonian.

F. L. KITCHIN.

Digitized by Google

VI.--MUSEUM OF PRACTICAL GEOLOGY

Work on the exhibited and stored collections has been still further impeded by the erection of wooden scaffolding to support the southern section of the roof. The supporting towers are now practically completed and repairs to the roof with a view to rendering it wind and watertight have now been begun. At present the exhibited collections are encased entirely in temporary wooden covers but it is hoped that, within a reasonable time, these coverings may be removed and the specimens once more made available for study and research. The present lack of facilities is causing serious inconvenience alike to the staff and the public.

In H.M. Government Pavilion at the British Empire Exhibition approximately 700 square feet of floor space were allotted to the Geological Survey and Museum and an exhibit was arranged to show the various aspects of Survey and Museum work. It included a series of 6 in. and 1 in. Geological maps, selected from coalfield and mining areas and from districts such as Mull which have yielded results of great scientific importance. Suites of specimens, with the appropriate maps, memoirs and reports, were shown to illustrate the geology of the London district, the economic resources of Great Britain in metallic and non-metallic minerals, and the use of fossils and rocks in the construction of geological maps and in the elucidation of such economic problems as the search for coal and underground water. The recently completed research into the petrography and chemistry of the bedded iron ores of England and Wales was illustrated by a series of typical specimens and photomicrographs. A large and typical set of enlargements of Survey photographs was also displayed.

In connection with the exhibition the Museum staff also prepared two loan exhibits : the first, a set of specimens to illustrate the origin and mode of occurrence of coal in Great Britain for the Mining Association Pavilion ; and the second, a series of polished agates from the Clent Hills, New Zealand, for exhibition in the mineral collection in the New Zealand Pavilion.

Considerable progress has been made with the scientific investigation and description of materials collected from outside sources. The memoir on iron ores, for which material was collected in 1923, has been completed ; it is now in the press and will shortly be issued as Volume XXIX of the " Special Reports on the Mineral Resources of Great Britain." This will include descriptions of the chemical and mineralogical constitution of the English and Welsh ores and their microstructure, with an account of new methods of preparing and staining the microsections developed in the present investigation.

The work of preparing sections of the ironstones and other rocks has been greatly facilitated by the use of a power-driven rock-slitting

Digitized by Google

machine which was constructed at the beginning of the year. This machine is of standard type with a horizontal slitting disc ; the rocks are fed against the disc with a rotational movement, the pressure being controlled by springs. Hand feeding is not used ; for the second cut, which can be made to a thickness of less than $\frac{1}{32}$ inch if desired, the slide with chip is supported on a special plate rotating horizontally. 160 sections have been prepared by Mr. Couper in the Mineral Laboratory and have been transferred to the Survey collection.

Progress has been made with the cataloguing of the reference collections. The large series of specimens of borings has been completely revised and rearranged ; a manuscript catalogue has been prepared and a card index commenced. In the mineral collection the card catalogue of the inventory has been completed to date and the cataloguing and labelling of the Ludlam Collection has been continued. Owing to the condition of the Museum building and the demand by the public for facilities in the library and map room it was found necessary to make an entrance to these departments from Piccadilly ; a large number of readers and enquirers have availed themselves of the privilege.

Numerous additions have been made to the library by purchase and donation, the following being the more noteworthy :—

Transactions, American Institute of Mining and Metallurgical Engineers ; 38 volumes.

Wanner, J., and others. Palaeontologie von Timor ; 13 volumes.

Contour maps of the Trencherbone seam, Lancashire Coalfield, by G. Hickling.

Akademiya Nauk, Leningrad ; about 50 volumes on the natural resources of Russia (presented by the Academy).

Proceedings, Royal Society of Edinburgh ; 23 volumes (presented by Dr. Flett).

Proceedings, Royal Physical Society of Edinburgh, 20 volumes (presented by Dr. Flett).

Several volumes of works by the late F. W. Harmer (presented by Sir S. F. Harmer).

The late Sir Jethro Teall's collection of pamphlets (presented by Lady Teall).

The presentation and exchange list has been revised and extended. This will make the publications of the Survey and Museum accessible to a larger public and also, it is hoped, lead to a continued increase in the presentations to the library from Scientific Institutions.

W. F. P. McLintock.

Digitized by Google

APPENDIX I

Some Recent Deep Borings in the London Basin

By Henry Dewey, J. Pringle and C. P. Chatwin

During the years 1923 and 1924 numerous borings have been made in the London Basin in search of water, and several have passed through the Upper Cretaceous rocks into the Lower Greensand. In one of the borings, where Lower Cretaceous beds were absent, Palæozoic strata were penetrated below the Gault. In view of the importance of the information gained respecting the underground extension of the Lower Greensand, it is here proposed to set forth a brief account of the new sections, and to illustrate by a sketch-map the distribution of this water-bearing formation under the London area.

1. Virginia Water Boring

For permission to examine the cores we are indebted to Dr. W. Moore, Superintendent of the Sanatorium, to Mr. W. Massey, M.V.O., and to Mr. Cross, Engineer of the Sanatorium.

The site of the borehole lies a few yards north of the Engine-house and about 200 ft. east of the railway cutting. O.D. ? 119.

Details of strata passed through at Virginia Water.

		Thickness. Ft.	in.	Depth. Ft.	in
Surface soil		4	0	—	
Loam		13	0	17	0
Gravel		0	6	17	6
Bagshot Sand	Yellow sand with small stripes of loam	8	6	26	0
London Clay	Drab clay, a lump of pyrites at 68 ft.	42	0	68	0
	Grey loamy clay	14	0	82	0
	Drab clay	179	0	261	0
	Septarian nodule	0	9	261	9
	Yellowish drab clay	31	3	293	0
	Flint pebbles and oyster shells	0	6	293	6
	Sandy clay	74	6	368	0
	Sandy clay with clay balls	38	0	406	0
	Septarian nodule	0	4	406	4
	Grey clay	5	8	412	0
	Pebbles	4	0	416	0
Reading Beds	Mottled clay	26	0	442	0
	Green and yellow sand	10	0	452	0
	Grey sand	21	0	473	0
	Dark olive green clay	6	0	479	0
	Ditto crumbly and slickensided	6	0	485	0
Upper Chalk	Soft white chalk with flints (fish remains and ossicles of *Uintacrinus*)	15	0	500	0
	Alternate beds of crystalline nodular chalk and grey marl: with fossils of the Planus Zone at the base	256	0	756	0

Digitized by Google

		Thickness. Ft.	in.	Depth. Ft.	in.
Middle Chalk	Similar chalk down to a depth of 880 ft. ..	124	0	880	0
	Below 880 ft. the marl seams die out and the chalk though still hard and nodular is white or grey and is thickly strewn with fragments of the shells of *Inoceramus labiatus:* at 910 ft. a specimen of *Rhynchonella cuvieri* was found ..	44	0	924	0
	Hard nodular gritty white chalk, with seams and stripes of grey marl. *Inoceramus labiatus* and *Rhynchonella cuvieri* throughout	13	0	937	0
	Fine-grained, free-dressing, pure white chalk .. .. about	1	0	938	0
	Greenish-grey laminated marl: the 'Plenus Marl'	4	0	942	0
Lower Chalk	Massive bedded grey chalk with many marl partings, often nodular and deeply slickensided	27	0	969	0
	Grey marly soft white chalk (*Ostrea vesicularis*)	36	0	1005	0
	Whitish-grey chalk without marl seams ..	32	0	1037	0
	Hard grey-green chalk	65	0	1102	0
	Soft dark grey-green sandy marl, highly fossiliferous and friable: *Schloenbachia varians*, abundant, *Turrilites* and other forms common	10	0	1112	0
	Soft dark grey-green sandy marl, friable and fossiliferous with *S. varians* and *Inoceramus crippsi*	10	0	1122	0
	Seam of marl	4	0	1126	0
	A concretion of grey sandstone	1	0	1127	0
	Chalk marl with nodules of sand; probably the junction between the Chalk Marl and the Upper Greensand	13	0	1140	0
Upper Greensand	Soft, green, glauconitic sandstone	20	0	1160	0
	Soft micaceous and gritty grey sandstone	8	0	1168	0
	Dark grey argillaceous sandstone, fine-grained with, occasionally, phosphatic nodules	20	0	1188	0
Gault	The last-mentioned beds pass downwards into dark grey sandy clay with Hoplitid ammonites at 1204 ft. and 1250 ft. ..	62	0	1250	0
	Similar Gault down to 1337 ft. where it became hard	148	0	1398	0
	[A band at 1358 ft.-1360 ft. was crowded with *Inoceramus sulcatus* and *Hamites intermedius*.]				
	Hard nodules of phosphate were found at 1424 ft. and at 1427 ft. Water broke through this basement bed and rose under pressure well above the surface	29	0	1427	0
Lower Greensand				?1430	0

The water-pressure is 45 lbs. per square foot and the temperature 70° F. On analysis the water proved to be potable. The borehole is lined with 15-inch tubes down to 456 ft.: 13½-inch tubes from 456 ft. to 516 ft.: 13-inch tubes to 1122 ft. and 8-inch tubes below.

Digitized by Google

The section may be summarized as follows for comparison with the borehole at Ottershaw, Chertsey :—

	Virginia Water. Ft.		Ottershaw. Ft.
Surface soil, etc.	17½		—
Bagshot Sand	8½		213
London Clay..	390		336
Reading Beds	69		100
Upper Chalk	271		
Middle Chalk	186	655	646
Lower Chalk	198		
Upper Greensand	48		45
Gault	239		296

The close parallelism between the two boreholes is apparent. The lower Tertiary Beds, however, are slightly thicker and the Gault and Upper Greensand slightly thinner in the Virginia Water borehole than at Ottershaw.

The Chalk at the Winkfield boring was 725 ft. thick and the Upper Greensand and Gault 295 ft. Virginia Water is approximately midway between Winkfield and Ottershaw as measured along the strike of the rocks.

H. D.

Palæontological Evidence in the Virginia Water Boring

By C. P. Chatwin

No fossils having been obtained from the Tertiary strata, the first point of interest was the horizon of the Chalk at the junction of the lowest Eocene bed. The finding of a few ossicles of *Uintacrinus* at once proved that the whole of the thick Coranguinum Zone had to be penetrated, as well as the lower divisions of the Chalk.

In view of the unusual lithological character of the Chalk, noted in the record of the section, it was particularly desirable to fix the main datum-lines, namely, the Reussianum Subzone and the Plenus Marls. In many parts of the country the Reussianum Subzone is readily distinguishable from the Chalk above and below by reason of its peculiar fossils, its special hardness, the presence of green-coated phosphatic nodules (when the Chalk Rock is developed), and its limited vertical thickness. In the core from this boring not much assistance was given by these criteria. The finding of a fragment of *Micraster* (with little more than its tuberculated surface visible) and of *Holaster* (of which the characteristic section only was to be seen) at 748 ft. still indicated the presence of the Upper Chalk. At the same level a small *Inoceramus* (*I. costellatus* Woods) suggested the horizon of the Reussianum Subzone. The only evidence at all corroborative was the occurrence at a slightly lower level of several examples of *Ventriculites*, such sponges being usually common in this Subzone. Green-coated nodules similar to those in the Chalk Rock were found at 760 ft.

Digitized by Google

Further down, *Terebratulina lata* Etheridge and the small form of *Inoceramus lamarcki* Parkinson indicated the Terebratulina Zone. Several examples of *Rhynchonella cuvieri* d'Orbigny, with its usual companion *Inoceramus labiatus* (Schlotheim), came from between 910 and 925 ft., and gave proof of the Cuvieri Zone of the Middle Chalk.

When seen in outcrop the upper limit of the Lower Chalk is usually conspicuous on account of the flaky weathering of the Plenus Marls. In an unweathered state, as in the cores, the marls were not easily discernible, but a greenish-grey, fine-grained laminated rock at 942 ft. yielded *Inoceramus crippsi* Mantell, var. *reachensis* Etheridge. This shell is characteristic of these marls, and is more frequent than the belemnite itself. Near this horizon the intensely hard white limestone (which occurs usually between an upper and lower layer of marl at the outcrop) was also present.

The upper portion of the Lower Chalk is as a rule not very fossiliferous. The core, however, yielded a small gryphaeate form of *Ostrea vesicularis* Lamarck[1] from near the top of this division (its usual horizon), but the specimen was not brought away. The Varians fauna was first seen at 1090 ft., where two examples of *Schloenbachia* cf. *varians* (J. Sowerby) were found. An abundant fauna, including several typical species of lamellibranchs, was collected from between 1110 and 1112 ft. From the glauconitic sandstone, which represents a small part of the Upper Greensand of more westerly areas, a sponge was collected at 1143 ft., but the specimen is not sufficiently well preserved for determination.

The first definite evidence of Gault fossils was obtained at 1189 ft., at which level *Pleurohoplites* occurred. Dr. Spath, who examined this and other ammonites from the core, regards this and *Discohoplites* (from 1200 ft.) as indicative of the Dispar Zone i.e., the upper part of Bed XIII (the top bed) of Jukes-Browne's classification.[2] The lowest depth from which Gault fossils were obtained was 1424 ft. The assemblage of ammonites from this level indicates the nodule bed at the base of Bed IX of the type section at Folkestone; some forms (*Anahoplites* and the tuberculate *Euhoplites*), as Dr. Spath points out, were probably derived from Bed VIII. *Inoceramus sulcatus* Parkinson was common in the lower part of the Gault down to 1400 ft. This shell by itself is sufficient evidence to indicate an horizon not lower than Bed VIII. The evidence of this core, therefore provides another instance of the overlap of the Upper Gault.[3]

The following is the list of fossils collected from the core; the figures in the left-hand column indicate the successive depths from which the specimens came. The specimens are identifiable by the

---

[1] Woods, H., 'Monograph of the Cretaceous Lamellibranchia' (*Pal. Soc.*), vol. lxvi, 1912, pl. lv, figs. 8 and 9.

[2] Jukes-Browne, A. J., 'Cretaceous Rocks of Britain' (*Mem. Geol. Surv.*), vol. i, 1900, p. 71; *see also* Spath, L. F., 'Monograph of the Ammonoidea of the Gault' (*Pal. Soc.*), 1923, p. 4.

[3] Kitchin, F. L., and J. Pringle, *Geol. Mag.*, 1922, p. 156.

Digitized by Google

numbers in square brackets, as registered in the MS. books in the Palæontological Department.

Depth in Ft.	
485	Uintacrinus sp. [AT. 3667].
485	Echinocorys scutatus *Leske* [AT. 3668–9].
485	Porosphaera globularis (*Phillips*) [AT. 3670].
748	Micraster sp. (probably M. praecursor *Rowe*) [AT. 3671].
748	Holaster planus (*Mantell*) [AT. 3672–3].
748	Inoceramus costellatus *Woods* [AT. 3674].
755	Ventriculites radiatus *Mantell* [AT. 3675].
758	Ptychodus rugosus *Dixon* (palatal tooth) [AT. 3676].
760	' Terebratula ' sp. [AT. 3677]
770	Ventriculites radiatus *Mantell* [AT. 3678].
780	Terebratulina lata *Etheridge* [AT. 3679].
786	,, ,, ,, [AT. 3680].
790	Inoceramus lamarcki *Parkinson* [AT. 3681.]
805	Terebratulina lata *Etheridge* [AT. 3682].
910	Rhynchonella cuvieri *d'Orbigny* [AT. 3683].
920	,, ,, ,, [AT. 3684].
924	Inoceramus labiatus (*Schlotheim*) [AT. 3685–87].
924	' Terebratula ' sp. [AT. 3688].
925	Discoidea dixoni *Forbes* [AT. 3689].
925	Inoceramus labiatus (*Schlotheim*) [AT. 3690–1].
936	Rhynchonella cuvieri *d'Orbigny* [AT. 3692].
942	Inoceramus crippsi *Mantell, var.* reachensis *Etheridge* [AT. 3693].
960	Holaster (fragment) [AT. 3694].
970	,, ,, [AT. 3695–6].
1025	Mantelliceras sp. [AT. 3697].
1025	Inoceramus crippsi *Mantell* [AT. 3698].
1025	,, etheridgei *Woods* [AT. 3698].
1025	Cardita *cf.* tenuicosta *J. de C. Sowerby* [AT. 3699].
1046	' Terebratula ' sp. [AT. 3700].
1065	Rhynchonella mantelliana (*J. de C. Sowerby*) [AT. 3701–2].
1065	Lingula sp. juv. [AT. 3703].
1065	Solarium sp. [AT. 3704].
1070	Lingula sp. nov. [AT. 3705–8].
1071	Lima (Plagiostoma) globosa (*J. de C. Sowerby*) [AT. 3709].
1086	Crassatellites *cf.* vindinnensis (*d'Orbigny*) [AT. 3710].
1090	Schloenbachia *cf.* varians (*J. Sowerby*) [AT. 3711]
1092	Pecten (Chlamys) fissicosta *Etheridge* [AT. 3712].
1092	Plicatula inflata *J. de C. Sowerby* [AT. 3712].
1092	Inoceramus crippsi *Mantell* [AT. 3713].
1098	Cucullaea sp. [AT. 3714].
1105	Corax falcatus *Agassiz* (tooth) [AT. 3715].
1106	Mantelliceras *cf.* costatum (*Mantell*) [AT. 3716].
1107	Turrilites tuberculatus *Bosc.* [AT. 3717].
1108	Schloenbachia *cf.* varians (*J. Sowerby*) [AT. 3718]
1108	Pleurotomaria sp. [AT. 3718].
1110	Schloenbachia *cf.* coupei (*Brongniart*) [AT. 3719].
1110	,, *cf.* varians (*J. Sowerby*) [AT. 3720].
1110	,, sp. [AT. 3721].
1110	Pecten (Chlamys) elongatus *Lamarck* [AT. 3722–3].
1110	,, (Neithea) *cf.* sexcostatus *Woods* [AT. 3724].
1110	,, (Syncyclonema) orbicularis *J. Sowerby* [AT. 3725–6]
1110	Lima (Mantellum) elongata (*J. de C. Sowerby*) [AT. 3727–9].
1110	Plicatula inflata *J. de C. Sowerby* [AT. 3730].
1110	Cucullaea mailleana (*d'Orbigny*) [AT. 3731].
1110	Hoplopteryx (fragments) [AT. 3732].

Digitized by Google

Depth in ft.	
1112	Schloenbachia *cf.* varians (*J. Sowerby*) [AT. 3733].
1112	,, sp. juv. [AT. 3734–5].
1112	,, sp. [AT. 3736–8].
1112	' Hamites ' sp. [AT. 3739].
1112	Pecten (Neithea) *cf.* sexcostatus *Woods* [AT. 3740].
1112	Grammatodon carinatus (*J. Sowerby*) [AT. 3741].
1113	Inoceramus crippsi *Mantell* [AT. 3742].
1140	,, ,, [AT. 3743].
1143	Sponge [AT. 3744].
1155	Diaulax oweni (*Bell*) [AT. 3745].
1157	Hemiaster sp. [AT. 3746–7].
1165	' Hamites ' sp. [AT. 3748–50].
1167	Pecten (Syncyclonema) orbicularis *J. Sowerby* [AT. 3751].
1174	Holaster sp. [AT. 3752–3].
1186	' Terebella ' lewesiensis (*Mantell*) [AT. 3754].
1186	Ostrea vesicularis *Lamarck* [AT. 3755].
1189	Pleurohoplites sp. [AT. 3756–7].
1200	,, [AT. 3758–9].
1200	Discohoplites (of the coelonotus group) [AT. 3760–1].
1202	Cymatoceras sp. [AT. 3762].
1204	Pleurohoplites sp. [AT. 3763].
1210	Dimyodon nilssoni (*Hagenow*) [AT. 3764].
1220	Avellana sp. [AT. 3765].
1248	Callihoplites ? sp. [AT. 3766–7].
1249	,, [AT. 3768].
1312	Cardita sp. [AT. 3769].
1316	' Hamites ' intermedius *J. Sowerby* [AT. 3770].
1358	Inoceramus sulcatus *Parkinson* [AT. 3771].
1359	' Hamites ' intermedius *J. Sowerby* [AT. 3772].
1359	Inoceramus sulcatus *Parkinson* [AT. 3773–4].
1360	,, ,, [AT. 3775].
1360	,, concentricus *Parkinson* [AT. 3776].
1360	' Hamites ' intermedius *J. Sowerby* [AT. 3777].
1361	Inoceramus sulcatus *Parkinson* [AT. 3778].
1362	Cardita tenuicosta *J. de C. Sowerby* [AT. 3779].
1362	Belemnites minimus *Lister* [AT. 3780].
1398	,, ,, [AT. 3781–2].
1398	Nucula pectinata *J. Sowerby* [AT. 3783].
1400	Dentalium decussatum *J. Sowerby* [AT. 3788].
1400	Inoceramus sulcatus *Parkinson* [AT. 3789].
1424	Euhoplites *aff.* solenotus *Seeley* [AT. 3784].
1424	Inflaticeras sp. [AT. 3785–6].
1424	Prohysteroceras sp. [AT. 3787].
1424	Euhoplites (of the tuberculatus group) [AT. 3790–1].
1424	Anahoplites sp. [AT. 3792].

2. Fobbing Boring

During the year 1924 the attention of the Geological Survey was called to a boring that was in progress at Fobbing, about 11 miles west of Southend, in Essex. This borehole was commenced in November 1923 at the bottom of the Fobbing Auxiliary Well, 551 ft. from the surface, and was carried down to 945 ft. by drilling, and from 945 ft. to the depth of 1152½ ft. by punching. The details of the well-section were communicated to the Geological Survey by Mr. E. C. Bilham, Engineer to the Southend Water Co., and afterwards

Digitized by Google

published in the ' Water Supply of Essex ' (*Mem. Geol. Surv.*), 1916, p. 157; and we are again indebted to Mr. Bilham for the details of the boring. These, together with such information as could be gleaned from an examination of the cores and smashed fragments are given below:—

		Thickness. Ft.	in.	Depth. Ft.	in.
River Drift	Passed through in well	17	6	—	
London Clay		139	10	—	
Lower London Tertiaries ..		141	2	—	
Upper and Middle Chalk 501½ ft. — Chalk	.. ..	252	6	551	0
Hard Chalk	.. ..	53	0	604	0
Soft white chalk with flint ..	.. .. ..	20	0	624	0
Soft white chalk	.. ..	115	0	739	0
Hard white chalk with some grey bands ..		61	0	800	0
Lower Chalk 112 ft. — Green band of rock [probably a marl, no sample kept]	.. ..	4	0	804	0
Hard white chalk	.. ..	42	0	846	0
Greyish-white marly chalk with fragments of *Schloenbachia varians* and *Inoceramus crippsi* between 870 ft. and 899 ft. ..		66	0	912	0
Upper Greensand 33 ft. — Dark green glauconitic sandy marl ..		15	0	927	0
Fine-grained calcareous sandstone with minute grains of glauconite and specks of mica	.. ..	18	0	945	0
Gault 182 ft. — Dark clay, punched through. [Between the depths of 1092 ft. and 1095 ft. clay obtained in trimming sides of borehole yielded the characteristic fossils of Bed IX of the Gault at Folkestone]	.. to	150	0	1095	0
Whitish quartz sand mixed with dark shale and grit, probably a conglomerate. A pebble of greenish rock (a volcanic ash) and one of coarse gritty sandstone were said to have been obtained. At base, well-rounded quartz grains embedded in a creamy calcareous matrix were found resting on Cambrian rocks		32	0	1127	0
Cambrian — Dark shales with *Acrotreta*; grey, greenish micaceous sandstones, hard greenish grey and grey quartzites, probably passed through in order given ..		25	6	1152	6

In respect to the Chalk and the Upper Greensand there is little to add to the details set forth in the above section. The Gault clays were punched through, but by a fortunate circumstance the hole was ' trimmed ' between the depths of 1092 ft. and 1095 ft., and from the clay thus obtained numerous fossils were collected. These included *Inoceramus sulcatus* Parkinson, *I. concentricus* Parkinson, *Belemnites sp.*, and *Hysteroceras varicosum* (J. Sowerby), shells characteristic of Bed IX of the type-section at Folkestone.

The base of the Gault is taken to be at the depth of 1127 ft. At that level water rushed in and rose to the height of 83 ft. above Ordnance Datum. From 1095 ft. down to 1127 ft. the sediment bore

Digitized by Google

evidence that a bed of conglomerate had been penetrated, and it is of interest to note that a similar rock, although classified with the Lower Greensand, was proved at the base of the Gault in the Cliffe Boring.[1] The conglomerate at Fobbing is regarded as the basement-bed of the transgressive Gault, and it rests on a quartzite of Cambrian age.

The Cambrian Rocks.—The debris collected between the depths of 1127 ft. and 1152½ ft. included dark shales, grey, greenish, micaceous sandstones, and thin bands of greenish-grey and grey quartzites. The shales yielded several fragments of the brachiopod *Acrotreta*, which, although apparently of Cambrian type, hardly helps to fix the precise position of the rocks within the Cambrian. The general aspect of the sandstones and quartzites suggests correlation with the Lingula Flags, and though they may possibly be older, the thin bands of quartzite appear to be identical with the 'ringers,' characteristic of that formation. J. P.

3. New borings in Kent and Hertfordshire

In Kent five boreholes have recently been sunk to the Lower Greensand. At Rainham the formation was touched at a depth of 870 ft. and consists of 50 ft. of sand and rock in alternate beds; it overlies Oxford Clay. The Gault was 169 ft. thick. At Rochester the borehole reached the Lower Greensand at a depth of 721 ft., and proved 20 ft. of sand under 185 ft. of Gault. At Gillingham the Lower Greensand was entered at 890 ft. below Ordnance Datum, and proved to be 17 ft. thick. It rests on a clay believed to be Oxford Clay. The Gault was 180 ft. thick. Details of the borings at Luton, Frindsbury, Pirton and Hitchin have already been published and are given in abstract only for comparison.

	Frindsbury.	Rochester.	Rainham.	Gillingham.	Luton.	Pirton.	Hinxworth, Hitchin.
Height above O.D.	15 ft.	8 ft.		5 ft.	92½ ft.	210 ft.	220 ft.
Gravel, etc. ..	—	59½	6	27	—	—	86
Upper Chalk ..	550	88½	695	688	455	203	
Middle Chalk ..		182					229
Lower Chalk ..		206					
Gault	180	185	169	180	194	255	214
Lower Greensand	79	20	50	17	57½	10	20
Corallian ..	proved	—	absent	absent	—	—	—
Oxford Clay ..	—	—	proved	proved	—	—	—

[1] Whitaker, W., 'The Water Supply of Kent' (*Mem. Geol. Surv.*), 1908, pp. 109 and 382. *See also* 'The Concealed Mesozoic Rocks in Kent' (*Mem. Geol. Surv.*), 1923, p. 185.

Digitized by Google

Copious supplies of water arose from the Lower Greensand: at Rochester the water overflows and the yield averages 17,000 gallons a day; at a depth of 186 ft. brackish water, which was shut out, flowed from the Chalk. At Luton the water rose to within 18 ft. of the surface and the yield from a 15½ inch bore was 216,000 gallons a day. At Gillingham, a 7¼ inch boring yields only 4,500 gallons a day. Good supplies were obtained at Pirton and Hitchin in Hertfordshire.

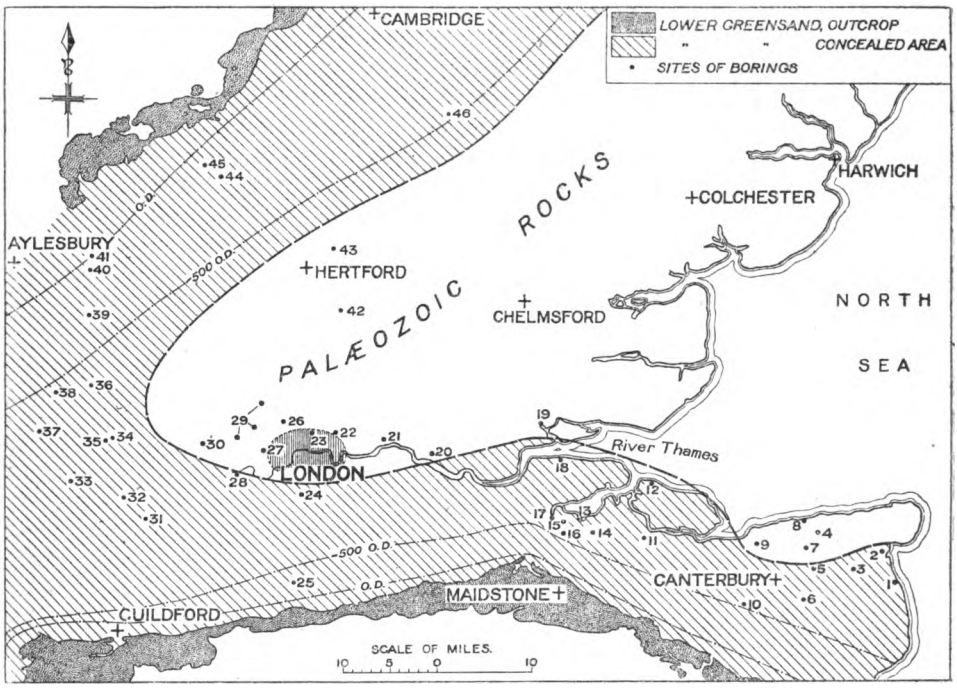

FIG. 9.—*Map showing outcrop and underground extent of the Lower Greensand.*

LIST OF BORINGS SHOWN ON MAP (FIG. 9).

1. Lydden Valley.
2. Ebbsfleet.
3. Ash.
4. Chitty.
5. Stodmarsh.
6. Harmansole.
7. Chislet.
8. Beltinge.
9. Blean Wood.
10. Chilham.
11. Bobbing.
12. Sheerness.
13. Gillingham.
14. Rainham.
15. Chatham.
16. Luton.
17. Rochester.
18. Cliffe.
19. Fobbing.
20. Crossness.
21. Beckton.
22. Mile End.
23. Meux's Brewery.
24. Streatham.
25. Caterham.
26. Kentish Town.
27. Chiswick.
28. Richmond.
29. Willesden Group.
30. Southall.
31. Ottershaw.
32. Virginia Water.

Digitized by Google

33. Winkfield.
34. Slough.
35. Cippenham.
36. Wooburn Green.
37. Maidenhead.
38. Great Marlow.
39. Missenden.
40. Tring.
41. Bulbourne.
42. Turnford.
43. Ware.
44. Hitchin.
45. Pirton.
46. Saffron Walden[1].

Since the Chalk that underlies areas where there is a thick development of Tertiary Beds is known to contain only insignificant quantities of water, close attention is now being paid to the Lower Greensand as a source of supply. Thus, the boring at Virginia Water was undertaken solely with the object of deriving water from this formation, as a supply was not expected from the Chalk. It is a matter of considerable importance, therefore, to ascertain the probable underground range of the Lower Greensand in the London Basin; and the sketch-map (Fig. 9) represents, as accurately as our present information permits, the distribution of this water-bearing formation in the region.

The concealed boundary of the Lower Greensand is now known over much of the south-eastern half of the Basin, and to some extent over the north-western portion, although few borings have reached the formation beneath the Chalk of Buckinghamshire and Hertfordshire. This lack of information is mainly due to the fact that the Chalk itself yields sufficient water to supply local needs, as it happens that the Tertiary Beds are either thin or absent in this area. It is also to be noted that the Lower Greensand outcrop in the neighbourhood of Aylesbury is not continuous, on account of the overlap of the Upper Cretaceous rocks, and frequently the Lower Cretaceous sands are preserved only in disconnected shallow depressions in the Jurassic rocks. It is known that the Lower Greensand and Gault were folded and eroded before the deposition of the Upper Gault clay. On p. 121 a boring at Marsh Hill, near Aylesbury, is recorded as having passed through Gault into Kimmeridge Clay without proving the Lower Greensand, although this formation outcrops less than a mile to the north.

The underground distribution is indicated by a line-pattern on the map, and the depth to the top of the Lower Greensand beneath the newer rocks is shown by contour lines drawn at Ordnance Datum and at 500 ft. below that level. The formation occurs at the depth of 1000 ft. below O.D. only at a few localities, for example, south and east of Windsor.

The sketch-map shows the part of the Palæozoic floor over which the Lower Greensand deposits are absent. It forms a broad tongue-shaped area, the southern boundary of which lies approximately parallel with the Thames Valley as far west as Southall. At this point the boundary swings sharply round and trends north-east-

[1] For details of these borings consult the various county water-supply memoirs issued by the Geological Survey; *see also* 'The Concealed Mesozoic Rocks in Kent' (*Mem. Geol. Surv.*), 1923.

Digitized by Google

wards. The general slope of the surface of the Palæozoic rocks is southerly. South of Saffron Walden it lies at a depth of 500 ft. below Ordnance Datum, whereas at Fobbing the floor is reached at a depth of 1057 ft. below that level. The slope is due to later movements that affected also the Lower Cretaceous rocks. In the London Basin the Palæozoic floor is formed of strata varying in age from Cambrian to Old Red Sandstone; but under East Kent Carboniferous rocks also have been proved.

H. D. ; J. P.

Digitized by Google

APPENDIX II

The Stratigraphical Relations between the Devon Red Sandstone (probable Barren Red Measures) and the Productive Coal Measures of Clackmannanshire

By D. Haldane, B.Sc.

In the course of the mapping of the Scottish coalfields about 55 years ago, it was concluded, from certain general evidence obtained in Ayrshire and Dumfriess-shire, that there was an unconformable junction between the Barren Red Measures, which form the highest subdivision of the Carboniferous System in Scotland, and the underlying Productive Coal Measures.

In 1909, however, Dr. C. T. Clough, as a result of mining information obtained during the revision of the coalfields of Sanquhar (one-inch Sheet 15), Cumnock (one-inch Sheet 14) and Mauchline (one-inch Sheet 22), showed that in these districts there is no evidence of important unconformity at this stratigraphical position.[1] In the above localities, which were taken as those in which there was strongest evidence in favour of the former interpretation, the unconformity had been inferred from mining information subsequently proved to be erroneous. At the same time Dr. Clough states that it does not necessarily follow that unconformability does not occur at this horizon in other localities.

It is of interest to note that no indication of unconformity has yet been traced at this horizon in the Wemyss district of Fife.[2]

In the Clackmannanshire map of 1882 (one-inch Sheet 39), of which no Explanation was published, the small patch of Barren Red Measures at the old Devon Ironworks, 2 miles north of Alloa and near the centre of the Carboniferous basin, is shown as lying irregularly on the Productive Coal Measures and somewhat to the east of the centre of the main basin, though no indication is given of any unconformability.

Certain additional information obtained during the recent revision of the Alloa and Clackmannan coalfield points to the conclusion that there is some stratigraphical break in the sequence at the junction between the Devon Red Sandstone (probable Barren Red Measures) and the underlying Productive Coal Measures, and that this break is due to an overlap of the strata, probably caused by a local erosion or a slight unconformity. The actual junction is not visible, and consequently the evidence is derived mainly by inference from mining records. Mining for coal and ironstone has been carried on for over a century in this area, and full details, particularly of the

[1] 'Summary of Progress' for 1909 (*Mem. Geol. Surv.*), 1910, p. 77.

[2] 'The Geology of Central and Western Fife and Kinross' (*Mem. Geol. Surv.*), 1900, p. 158.

Digitized by Google

upper seams, are not now available, though the Alloa Coal Company Ltd., who own Devon Colliery, very kindly furnished all the records and plans in their possession.

The accompanying sketch map (Fig. 10) shows the main geological features of the area. Devon Colliery is situated at the top

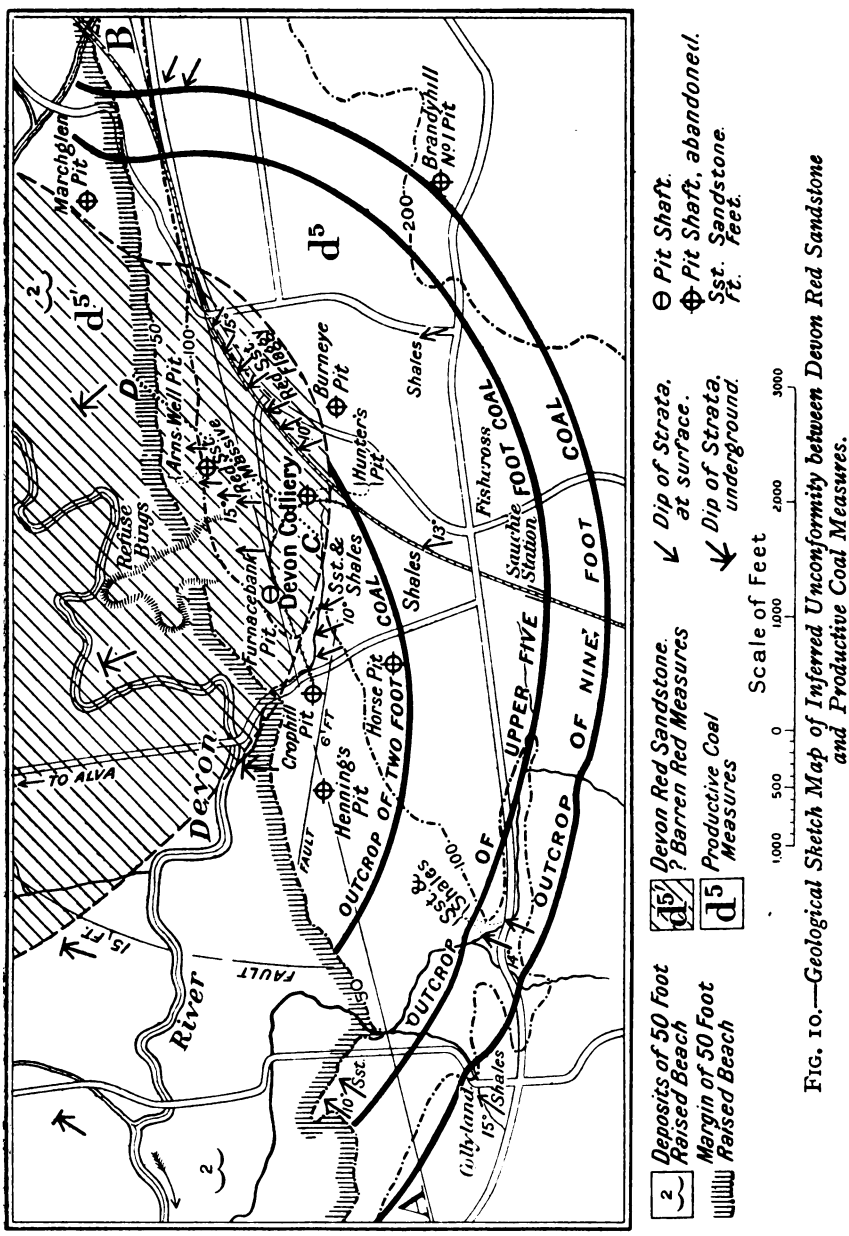

FIG. 10.—*Geological Sketch Map of Inferred Unconformity between Devon Red Sandstone and Productive Coal Measures.*

Digitized by Google

of the steep bank which rises along the south edge of the flat carse of the Devon valley. In this bank there are several old quarries to the east of the colliery, in one of which a 30-ft. face of massive red sandstone is exposed. South-east from the quarries red sandstone of a more flaggy nature is seen in the cutting on the railway. The above are the only visible exposures of the Devon Red Sandstone, and they seem to show that this group occupies a basin, the centre of which lies to the north of Arns Well Pit. But the exposures of white sandstones and shales belonging to the Productive Coal Measures, taken in conjunction with the structure shown on the plans of the workings of several seams, indicate that the centre of the basin of Coal Measures lies further to the north-west, in the vicinity of the road to Alva. The basins of the two groups of strata are thus eccentric, their centres being about half a mile apart.

The right-hand edge of the vertical section (Fig. 11, p. 141) gives the sequence of the upper coal seams in Furnacebank Pit, of which all the details are recorded in the Vertical Section published by the Geological Survey in 1877. The base of the red sandstone is here 12 fathoms down and 11 fathoms above the Two Foot Coal; no other red sandstone was met with in the shaft except at horizons below the Four Foot Coal. In all the other pits, unfortunately, nothing beyond the depths of the chief coals is known, but these are sufficient to show that the Two Foot Coal lies at the following levels :—

Arns Well Pit	..	..	..	..	12½ fms.	below	the surface.
Hunter's Pit	..	..	..	..	9 ,,	,,	,, ,,
Horse Pit ..	..	..	..	..	3½ ,,	,,	,, ,,
Crophill Pit	..	..	..	..	17½ ,,	,,	,, ,,
Henning's Pit	..	..	..	about	21 ,,	,,	,, ,,
Burneye Pit	..	..	..	,,	12½ ,,	above	,, ,,
Marchglen Pit	..	..	..	,,	13 ,,	,,	,, ,,

From this information, together with the dip in the workings, the outcrop of the seam can be drawn with considerable accuracy, and its course is such that either this coal, or the white sandstones, dark shales and rough coals which are found above it in Furnacebank Pit, ought to crop out in the railway cutting, instead of the flaggy red sandstones which are actually found. Again, if the Furnacebank Pit sequence were constant towards the west, about 10 fms. of red sandstone should occur at the top of Henning's Pit, and about 7 fms. at Crophill Pit, whereas the exposures in the burn close to the latter show white sandstones and dark shales clearly belonging to the Productive Coal Measures, and there is every reason to believe that the red sandstone is entirely absent in the former shaft. The base of the red sandstone thus lies probably about 20 fms. above the Two Foot Coal in Henning's Pit, 11 fms. above it at Furnacebank, and some distance below its position near the railway cutting; towards Marchglen Pit the base may have descended to an even lower level. These anomalies cannot be explained by faulting, for the whole area is remarkably free from faults, the only two known 'hitches'

Digitized by Google

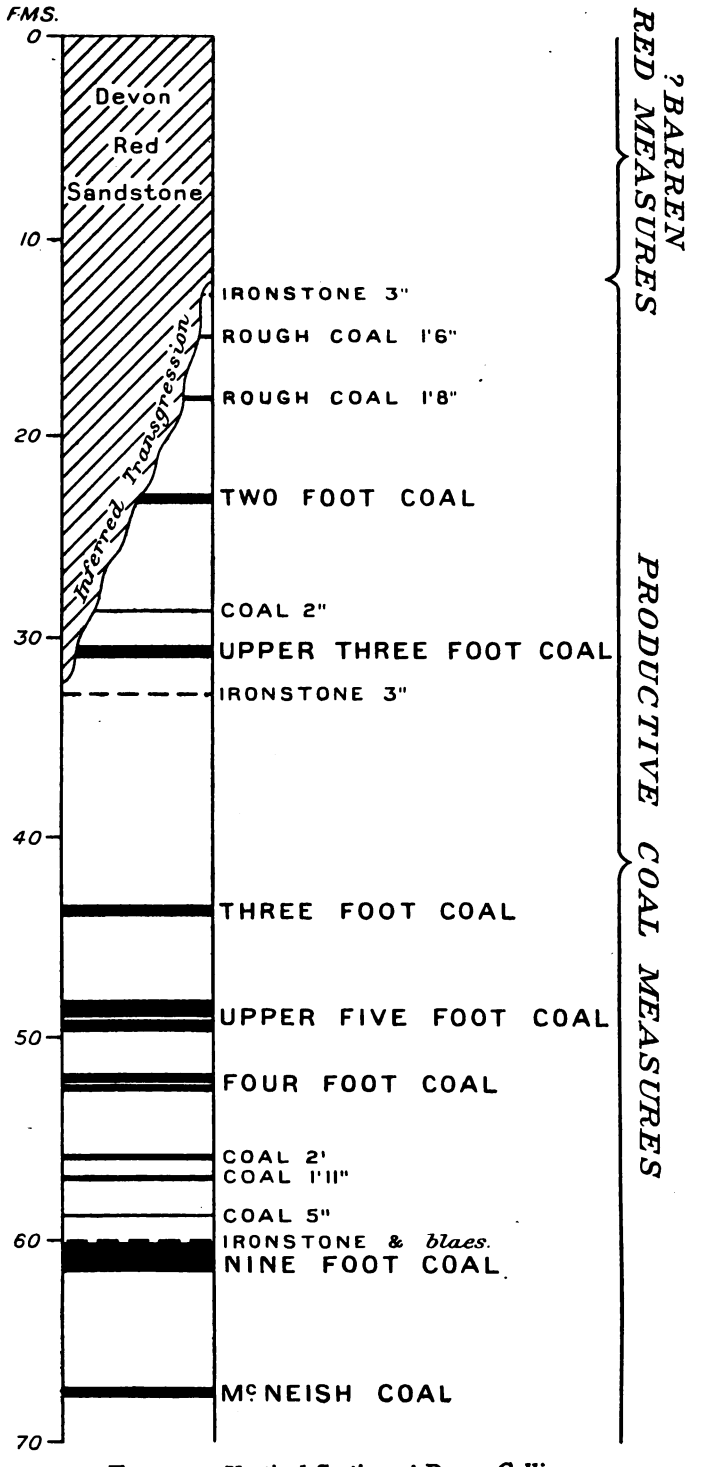

FIG. 11.—*Vertical Section at Devon Colliery.*

Digitized by Google

being those indicated on the sketch map. The natural inference is that the red sandstones are transgressive across the outcrops of the underlying strata, and the thickness of the beds transgressed is probably not less than 120 ft.

A curious feature is met with in the Two Foot Coal workings which suggests a similar conclusion. Along the dotted line C–D on Fig. 10, as the coal was wrought towards the rise from the north-west, it was found that the top of the seam was ' burnt ' to a depth of 6 to 10 in. This can scarcely be accounted for by igneous intrusions, which are unknown in the district except along the Ochil Fault, more than a mile to the north ; nor by the action of hot slag through the overlying sandstones—indeed the slag bings from the old Devon Ironworks lie well to the north-west of this line. The term ' burnt ' is, however, frequently applied by miners to coal that is rendered worthless by causes other than heat (such as impregnation with mineral matter, proximity to an outcrop, &c.) and such was almost certainly its meaning in this instance. As already shown, the Two Foot Coal rises to meet the base of the red sandstones not far from the line C–D, and it cannot have reached the surface of the ground at any period subsequent to their deposition. It is thus by no means unlikely that the ' burning ' is due to late Carboniferous weathering of the coal, at and near its outcrop at that time.

To sum up, an unconformity between the Devon Red Sandstone and the Productive Coal Measures is the simplest explanation of the figures quoted above, while the eccentric disposition of the respective basins of these rock groups, and the ' burning ' of the Two Foot Coal, are most readily accounted for in the same way.

It may be remarked in conclusion that Skipsey's Marine Band, which is now taken as marking the top of the Productive Measures in the Central Coalfield of Scotland, and which has equivalents in Ayrshire, Fife and Midlothian[1] is not known from this area. The 3-inch ironstone band, associated with shales, which occurred at a depth of 12½ fms. in Furnacebank Pit, was taken as the top of the Productive Measures in the Vertical Section of the Clackmannanshire strata published by the Geological Survey in 1877 ; but no fossils have been recorded from this ironstone, now no longer accessible, so that we can neither assert nor deny its correspondence to Skipsey's Marine Band. On the other hand, R. Bald, who[2] gives the section at Furnacebank Pit and refers to it as " accurately ascertained," appears to have noticed only mussels " similar to the fresh water mussel " among the shells of the Clackmannan coalfield. If we could take this to be satisfactory evidence that marine fossils, and therefore Skipsey's Band, are definitely missing in the pit shaft,

[1] Smith, J., and C. T. Clough, ' The Marine Beds near the Base of the Upper Carboniferous Red Barren Measures of Scotland,' ' Summary of Progress ' for 1907, *Mem. Geol. Surv.*, p. 127. *See also* ' The Geology of the Glasgow District,' *Mem. Geol. Surv.*, 1925, pp. 93, 94.

[2] ' On the Coal-formation of Clackmannanshire,' *Mem. Werner. Soc.*, Vol. 1, 1811, pp. 493, 494, 502, 503.

Digitized by Google

the absence of the Band here only among the Scottish coalfields might be interpreted as an additional result of, and argument for, the unconformity.

It should, however, be remembered that until proof is obtained that Skipsey's Band is not present in the deeper part of the coalfield, *above* the Devon Red Sandstone, there is always a slight possibility that the latter may be of earlier date than the true Barren Red Measures of the Scottish Carboniferous, although lithologically, this sandstone bears a strong resemblance to the Barren Red Measures of Lanarkshire and Ayrshire, and it is markedly dissimilar to the Ayrshire Permian sandstones.

D. H.

Digitized by Google

INDEX

Ach'uaine, 117.
Acoustical detection of underground deposits, 3.
Acton, T. A., 24.
Adbaston, 41, 42.
Adwalton, 52.
Afton Colliery, 95.
Agnew, C. Morland, 24.
Ainley Top, 50.
Airdrie, 96.
Aire-Calder Watershed, 55.
Aire Valley, 53.
Airth, 113.
Albyfield, 77.
Aldershot sheet, 9, 16, 34–36.
Allan, D. A., 115.
Allan, J. K., 19, 108, 112, 113, 114.
Allerton, 55, 56.
Alloa Coal Co., 139.
Alloa Coalfield, 15, 29, 138.
Allt Cathair Bàna, 117.
Allt Sail an Ruathair, 117.
Alnwick, sheet, 13, 17, 31, 81, 83.
Alva, 140.
Amianthus Mines, New, Proprietors of, 25.
Anderson, E. M., 21, 93, 96, 116.
Anderson, W., 17, 81, 82, 83, 87.
Anglezarke Moor, 66.
Anglezarke reservoir, 66.
Anshaw Clough, 67.
Ardnamurchan, map and memoir, 14, 20, 21, 116, 118.
Ardochrig Hill, 104.
Argyllshire, 30, 118.
Arnesalloch Burn, 107.
Arns Well Pit, 140.
Ash, 35, 36.
Ash Vale, 35.
Ashmore, G. P., 24.
Ashton, 63.
Ashton Moss Colliery, 62.
Ashton-under-Lyne, 59, 62, 63.
Assistance outside the Survey, 3.
Astley's Pit, 63.
Auchtertool, 111.
Avon, River (Lanarkshire), 104.
Avon Water, 104.
Aylesbury, boring near, 121, 136.
Ayr, Heads of, 89, 90, 91, 95.
Ayrshire, 14, 19, 21, 29, 30, 31, 89–95, 96, 124, 138, 142, 143.
Ayrshire rock analyses, 117, 118.
Badger Gate Clough, 53.
Bailey, E. B., 13, 14, 19, 89-95, 96, 116.
Bailiffe Bridge, 51.
Bald, R., 142.
Banff memoir, 13, 20, 116.
Bank, 94.
Bankend, 96, 103, 105, 106.
Bankhouse Wood, 48.
Bardsley, 63.
Bargany House, 91.
Barnsley, 32.
Barrow, 38, 44.
Batley, 52.
Batley, Upper, 52.
Bayzand, C. J., 10.
Beaumont, A. G., 58.
Beckermet, 75.
Beinn Hiant, 118.
Bell Dean, 56, 57.
Belmont, 66, 67.
Benarty Hill, 108.
Benthall, 39.
Benthall Edge, 38.
Bentley Fault, 10, 33.
Berwick-on-Tweed, map and memoir, 13, 17, 18, 31.
Biggar, 100.
Bilham, E. C., 132, 133.
Bincknoll Dip, 37.
Binn, 108.
Binnend, 108.
Birkenshaw, 49.
Birkenshaw Bottom, 52.
Birmingham, map and memoir, 10, 17, 32.
Birstal, 52.
Birstal, Upper, 52.
Bisat, W. S., 11, 49, 50, 59.
Bishop Hill, 77.
Bishop's Offley, 42.
Bishop's Wood, 42, 44.
Bisley Camp, 35.
Black Burn, 82.
Black Pots, 76.
Blackmore Heath, 36.
Blacksike Colliery, 77, 78.
Blackwater, River, 36.
Blackwater valley, 35, 36.
Blagdonburn, 83.
Blagdonburn Burn, 88.
Blairhall, 112.
Blueburn, 88.

Digitized by Google

Boardman Edge, 61.
Boat How, 72.
Bodinglee, 104.
'Boggs, The,' 56.
Bolton (Lancashire), 65.
Bolton (Northumberland), 82.
Bondicarr, 88.
Bondicarr Fault, 86.
Boreland Glen, 90.
Borough Pit, 63.
Boston, Lord, 24.
Boulton, W. S., 122.
Bourblaige, 118.
Bower Colliery, 63.
Bowl Shaw Clough, 51.
Bradford, 50, 54, 56, 57, 64.
Bradford Brick and Tile Co., 51.
Bradley Clough, 53.
Braggers Hill, 39.
Brainshaugh, 84.
Brampton, sheet, 12, 17, 31, 76, 79, 80.
Brecknockshire, maps, 29.
Bridgnorth, 39.
Brigham, 72, 73.
Brighouse, 50, 51.
Brighton, map and memoir, 4, 9, 17, 19.
Brinscall, 66.
Bristol coalfield, 29, 30.
British Empire Exhibition, exhibit, 5, 22, 23, 121, 125.
Broad Carr, 61.
Broad Street, 36.
Broadlea Burn, 107.
Broadtown, 37.
Brock Burn, 105.
Brockholes, The, 43.
Brocksbank, —., 64.
Brockton Brook, 45.
Brockton Hall, 45.
Bromehead, C. N., 9, 11, 12, 16, 24, 32, 45–58.
Bromiley, 67.
Brookfoot, 49–50.
Brook's Stone Co., 58.
Broom Hill, 57.
Broomhill, 84, 85, 86, 88.
Brora coalfield, 31.
Brora, map and memoir, 14.
Broseley, 38, 41, 44.
Broughton, 42.
Broughton Crags, 72.
Broughton Moor, 75.
Brown, G. F., 24.
Brown Carrick, 89.
Brown Edge, 61.
Brown Hill, 104.
Browncastle, East, 105.
Bruntcliffe, 52.
Buckinghamshire, 136.
Buckman, S. S., 123.
Buckstones Hill, 47.
Bullock's Hall Colliery, 87.
Bunker's Hill, 69.
Burderop Wood, 37.
Burham, 22.
Burnett, G. A., 17, 81, 87.
Burneye Pit, 140.
Burnley, 61.
Burnside, 105.
Burnt Edge, 68.
Burnt Rig, 103.
Burntisland, 108.
Bury, 61.
Bwana M'Kubwa Copper Mining Co., Ltd., 24.
Byers Fell, 77.

Cairngryfe Hill, 102.
Calder, 87.
Calder River, 48, 76.
Calder valley, 48, 53, 75.
Calder Water, 105.
Callaly, 82, 83.
Calvington, 42.
Camas na Cloiche Moire, 118.
Camberley, 35.
Cambrian rocks, 38, 122, 133–134, 137.
Camerton, 74.
Campbeltown coalfield, 29, 30, 31.
Canonbie coalfield, 29, 30, 31.
Cantrill, T. C., 10, 16, 38–45.
Capledrae, 113.
Carboniferous rocks, 27–33, 39–42, 46–53, 59–64, 65–69, 72–75, 76–79, 82–87, 90–95, 104–107, 108–114, 120, 123–124, 138–143.
Cardenden, 108.
Carlisle, map and memoir, 13, 17, 18, 31, 76, 80.
Carmarthenshire, maps, 29.
Carmichael, 99, 101, 102.
Carmichael Burn, 97, 99.
Carmichael Fault, 101.
Carnock, 108.
Carperley Beck, 55.
Carruthers, R. G., 13, 17, 31, 81–88.
Cartington, South, 88.
Castle Beck, 76.
Castle Carrock, 76, 78, 79.
Castle Hill, 53.
Caughley Old Hall, 41.
Central Coalfield of Scotland, 14, 19, 21, 29, 31, 96, 113, 142.
Cessnock Castle, 124.
Chalmerston Hill, 95.
Chamber Colliery Co., 59, 62, 63.
Chapel, 106.
Charlestown, 109.

Digitized by Google

Chat Hill, 57.
Chatwin, C. P., 9, 22, 120, 121, 123, 127–137.
Cheadle Coalfield, 32.
Chellow Dean, 56.
Chemical Work, 2, 22, 117–119.
Chertner Burn, 83, 88.
Cheshire maps, 29.
Cheswardine, 41, 42, 44.
Chevington, East, 86.
Chevington, West, 87.
Cheviots, 81, 88.
Chobham Ridges, 35, 36.
Chorlton-cum-Hardy, 65.
Clackmannan, 14, 20, 29, 30, 31, 138–143.
Clayton, 51, 55.
Clayton Beck, 57.
Cleator Moor, 70, 74–75.
Clee Hill Coalfield, 29, 30, 32.
Clee Hills, 40.
Clevancy, 37.
Cliffe boring, 134.
Clifton, 70, 74.
Clough, C. T., 82, 138.
Clyde, River, 100, 101.
Cnoc a' Choire Bhuidhe, 117.
Coalbrookdale coalfield, 29, 38, 43.
Coalburn, 96, 105.
Coalfield revision, progress, 27–33.
Coalfield work, concentration on, 2.
Coalmoor, 44.
Coalport, 41.
Coatbridge, 96.
Cobbett Hill, 35.
Cobbold, E. S., 122.
Cock Hill, 50.
Cockersdale, 52.
Cocking Lane, 50.
Cockpit Well, 82.
Cold Fell, 72, 76.
Coll, map and memoir, 14, 20, 116.
Colne Valley, 46, 48, 53.
Colwall Tunnel, 16.
Compton, 34.
Compton Bassett, 37.
Cop Mere, 44.
Copley, 48, 53.
Copper Ores report, 9, 15, 17, 19, 34.
Coquet, River, 81, 84, 88.
Coquet valley, 82, 83.
Cornwall, 28, 34.
Corton Manor, 37.
Cottingley Valley, 55.
Counting Hill, 68.
Couper, G. L., 126.
Coventry sheet, 32.
Covington, 101, 102.
Cowdenbeath, 15, 112.
Crag Fell, 76.
Craigmark, 94.
Creag na Fearna, 117.
Cretaceous rocks, 34, 36–37, 121, 122, 127, 128, 129–137.
Cringle Hall, 65.
Crophill Pit, 140.
Crosland Moor, 48.
Cross, N. F., 127.
Crown Prince Wood, 35.
Cuff Burn, 104.
Culross, 113.
Cumberland, 12, 17, 28, 29, 30, 31, 70–80.
Cumnock coalfield, 138.
Cumnock, New, 89, 94, 95.
Cumrew, 77, 79.
Cunningham Baidland, 124.
Cunnington, Lt.-Col. R. H., 24.

Dailly, 89, 90, 91, 92, 93.
Dailly, New, 90.
Dairypit, The, 38.
Dalmellington, 89, 94, 95.
Dalry, 124.
Dalrymple, 89, 90.
Dalton, 53, 86.
Dartford, map and memoir, 9, 17, 19, 34, 123.
Darwen, 65, 67.
Darwen Hill, 67, 68, 69.
Davies, A. M., 24.
Dawkins, Sir W. Boyd, 60.
Dawley, 38.
Dean, 39
Dean Brook (Lancs.), 67.
Dean Brook (Salop), 38.
Dean Corner, 44.
Dean, Forest of, 29, 30, 40.
Deanhead valley, 46.
Debdon Burn, 83.
Denbighshire, maps, 29.
Denholme, 55–56.
Denholme Beck valley, 50, 56.
Denholme Edge, 50, 55.
Dent, 71, 75, 76.
Denton Fell, 77.
De Rance, C. E., 64.
Derbyshire, 29, 31, 32, 49.
Derbyshire, Water Supply memoir, 17.
Derwent, River, 70, 73, 74.
Derwent valley, 74, 75.
Devon Colliery, 139–141.
Devon Ironworks, 142.
Devon valley, 140.
Devonshire, 28.
Devonshire, Duke of, 25.
Dewey, H., 9, 10, 16, 34–37, 127–137.
Didsbury, West, 65.
Dimple, 66.
Dines, H. G., 9, 16, 34, 35, 36.

Digitized by Google

Dinham, C. H., 14, 15, 19, 96, 108–115.
Distington, 72, 74.
Dixon, B. E., 118.
Dixon, E. E. L., 16, 17, 44, 70, 72.
Dodhead Quarry, 108.
Doles Hole, 77.
Doley, 44.
Donations to Museum, List of, 24–25.
Doncaster, 121.
Doon, River, 90.
Dorking, 34.
Dorsetshire, Water Supply memoir, 3, 8, 17.
Doseley, 39, 43.
Douglas coalfield, 14, 31, 96–107, 123, 124.
Down Place, 35.
Drighlington, 49.
Dron, R. W., 93.
Drumalbin, 100.
Drumgrange Burn, 94.
Dukinfield, 62, 63.
Dumbartonshire, maps, 29, 30.
Dumfriesshire, 29, 30, 138.
Dunfermline, 15, 19, 31, 108, 109, 112.
Dungavel Hill, 100.
Dunure, 89.
Durham and Northumberland district, 17, 28, 29, 30, 81–88.
Dyson, W. H., 121.

East Browncastle, 105.
East Chevington, 86.
East Lothian, 29.
Eastfield, 97, 99.
Eastwood, T., 17, 70, 72, 74.
Eccleshall, 38, 42, 45.
Eden, River, 76, 79, 80.
Edgworth, 65.
Edinburghshire, maps, 30.
Edlingham, 81, 82.
Edmunds, F. H., 8, 9, 16, 34, 35, 36.
Edwards, Wilfrid, 8, 10, 16, 34, 36, 37, 46, 48–49, 50, 51, 52.
Egerton, 66.
Egremont, 70, 74, 75.
Egypt (Yorks.), 50.
Ehen, River, 75.
Eighton Banks, 87.
Electrical detection of underground deposits, 3.
Elgin Collieries, 112.
Elland, 48, 49, 50.
Elland Sewage Works, 53.
Ellerton, 44.
Elles, Miss G. L., 38, 71.
Ennerdale, 70, 75.
Ennerdale, Lower, 70.
Ennerdale valley, 70, 71, 75.
Exley, 49.
Eyles, V. A., 19, 89, 91, 93, 94.

Failsworth, 62.
Fairweather Green, 51.
Falkirk sheet, 14.
Fallowfield, 64, 65.
Fallside, 104.
Farnborough, 36.
Farther Isle, 55.
Feldtmann, W. R., 24.
Felling, High, 87.
Felton, 88.
Fenwick, 118.
Field units allocation, 2.
Fife Coal Co., 111.
Fifeshire, 29, 30, 31, 108–115, 138, 142.
Fill Brook, 69.
Fireclays report, 17, 18.
Firth House Wood, 46.
Flett, J. S., 7–25, 27–33, 126.
Flimby, 75.
Flint, map and memoir, 10, 17, 18, 29, 32.
Floutern Tarn, 70.
Fobbing, boring at, 121, 132-134, 137.
Ford, sheet, 13, 17.
Foreside Top, 50.
Forest of Dean, 29, 30, 40.
Forest of Wyre, 29, 30, 32.
Fossil Plants of the Carboniferous Rocks, monograph, 4, 8, 17, 19, 22, 120.
Fowler, A., 17, 81, 82, 84, 86, 88.
Fox Hills, 35, 36.
Foxton, 84.
Frimley, 35, 36.
Frindsbury boring, 134.
Frizington, 72.
Furnacebank Pit, 140, 142.

Gaika Gold Mining Co., Ltd., 24.
Gairs, 76.
Galston, 124.
Gardrum, 118.
Garf Water, 100.
Garmelow, 44.
Garpel Water, 124.
Geikie, Sir A., 7, 28, 89, 95, 97, 100.
Gelt, River, 78, 79.
Gelt valley, 76, 79.
Genn, F., 24.
Gibson, W., 1, 7, 10, 12, 17, 32, 42.
Gillingham, boring at, 134, 135.
Glacial and Post-Glacial, 43–45, 53–58, 65, 75–76, 79–80, 87–88.
Glamorganshire, maps, 29.

Digitized by Google

Glasgow district memoir, 14, 19, 21, 96, 108, 109.
Glebe Burn, 107.
Gledholt, 50.
Glent, 60.
Globe and Phœnix Gold Mining Co., Ltd., 24.
Gloucestershire Water Supply memoir, 17.
Golcar, 47.
Goldney, F. H., 24.
Goldstone, 44.
Goldstone Common, 42.
Golightly, Mrs., 24.
Golspie, map and memoir, 14, 19, 21.
Gomersal, 52.
Goring Guide, 19.
Gosforth, South, 87.
Grange Brow, 67.
Gravitational detection of underground deposits, 3.
Great Hill, 66.
Great Sowdley, 42.
Great Tosson, 82.
Green, A. H., 47, 48.
Green, J. F. N., 71, 72.
Greetland, 48.
Greetland Moor, 48.
Guildford, 36.

Haddingtonshire, maps, 30.
Haddricksmill, 87.
Hadstone, 86.
Hagshaw Burn, 103.
Hagshaw Hill, 96, 101, 103.
Haining Burn, 78.
Haldane, D., 19, 108, 109, 112, 113, 114, 138–143.
Hale, 75.
Halifax, 48, 49, 50.
Halliwell Fold Bridge, 66.
Haltonlea Gate, 76, 77, 78.
Hangster's Gate, 44.
Happendon Bridge, 106.
Harden valley, 55, 56, 57.
Harlow Hill, 86.
Harmer, F. W., 122.
Harmer, Sir S. F., 126.
Harrington Colliery, 74.
Harrop Edge, 50, 56.
Hartshead, 61, 62.
Hartshead Colliery, 51.
Hartside Burn, 97.
Hatch Brook, 66.
Hatch, The, 39, 40, 43.
Hauxley, 86.
Havannah, 78.
Hawley, 36.
Haycliffe Hill, 51.
Heads of Ayr, 89, 90, 91, 95.
Heath, Robert, and Low Moor, Ltd., 58.
Hebble valley, 53.
Hedgeley, 87.
Hempshaws, Higher, 66.
Henley Park, 35.
Henning's Pit, 140.
Henry Pit, 77.
Hensingham, 72.
Hertford, map and memoir, 9, 17, 18, 34.
Hertfordshire, borings in, 134, 135, 136.
Hester, S. W., 22, 121.
Hickling, G., 60, 64.
High Brow, 67.
High Felling, 87.
High Gelt Bridge, 78.
High Hynam, 78.
Higher Hempshaws, 66.
Highland district work, suspension of, 2, 13.
Highway, 37.
Hillebrand, W. F., 23, 119.
Hillhouse, 53.
Hinstock, 41, 42, 44.
Hinxworth boring, 134, 135.
Hitchin boring, 134, 135.
Hobberlaw, 83.
Holbrook Coppice, 39.
Holcombe Brook, 67.
Hollin Park, 55.
Hollingworth, S. E., 17, 70, 71, 72, 75, 76, 77, 79.
Hollinwood, 62, 63.
Holmfield, 49, 53.
Holt Head, 47.
Holy Island, map and memoir, 13, 17, 18.
Honley, 51, 53.
Hook, 35.
Horne, J., 15, 29, 97, 99, 103.
Horse Pit, 140.
Horsehay, 43.
Horsehay Brook, 44.
Horton Bank, 51.
Horwich, 68, 69.
Hough Hill, 61.
Houldsworth Colliery, 93, 94.
How Hills, 72.
Howden Clough, 52.
Howgate Hill, 101, 102.
Howgate Mouth Fault, 101, 102.
Howgill, 77.
Howgill Beck, 77.
Howgill Fell, 80.
Howick, 81, 84, 85, 86.
Howick Burn, 88.
Huddersfield Brick Co., 53.

Digitized by Google

Huddersfield sheet, 11, 16, 32, 46–58.
Hughes, —., 59.
Hull, E., 60, 61, 64.
Humbleton, 82.
Hunter's Pit, 140.
Huntington, 40.
Huntly memoir, 13, 20, 116.
Hurlet, 109.
Hynam, High, 78.

Igneous Rocks, 43, 72, 81–82, 95, 101–104, 114–115.
Ilderton, 81, 82.
Illingworth, 48.
Illingworth Fault, 53.
Imperial College of Science and Technology, Governing Body of, 24.
Invershin, 117.
Invertiel, 111.
Iona memoir, 13, 20, 116.
Iron Ore analyses, 117.
Iron Ores, Special Reports, 13, 15, 17, 19, 22, 23, 119, 125.
Ironbridge, 38, 43.
Ironbridge Gorge, 38.
Irwell, River, 65.
Irwell Valley, 65, 67.
Irwell Valley Fault, 64, 67.
Isle of Man, 34.
Islip Iron Co., Ltd., 24.

Jackson, J. W., 60.
Jones, O. T., 65, 120.
Jones, R. C. B., 17, 59, 65, 66.
Jowett, A., 55.
Jukes-Browne, A. J., 130.
Jurassic Rocks, 37, 120, 121, 123, 134.

Keighley, 50.
Keirs Castle, 93.
Kendall, J. D., 75.
Kendall, P. F., 60.
Kent, borings in, 134–135, 137.
Kerse Loch, 93, 94.
Kersepark Farm, 91.
Kidner, N. W., 24.
Kidston, R., 4, 8, 22, 120, 121.
Kidston bequest, 4, 8, 22, 24, 121.
Kilbirnie, 124.
Kilmarnock sheet, 14, 19.
King Alexander's Crag, 109.
King, W., W. 24.
Kinghorn, 15, 108, 109.
Kinross district, 108–115, 124.
Kirk Hill, 99.
Kirkcaldy, 108, 109, 110, 111–112, 113.
Kirklees Park, 53.
Kirknewton, 88.
Kirkoswald, 89.
Kitchin, F. L., 22, 120–124.
Knighton, 44.
Knock Hill, 114.
Knott Hill, 62.
Knox, J., 19, 108, 109, 111, 112, 113, 115.
Krumlin, 46.

Lacroix, A., 24.
Lake district, 34, 116.
Lake district erratics, 80.
Lambley, 78.
Lamington, 96, 100.
Lamplugh, 71.
Lanark sheet, 19.
Lanarkshire, 29, 30, 31, 96–107, 143.
Lancashire, 17, 28, 29, 30, 31, 46, 49, 59–69.
Lane, G. W., 24.
Langot Valley, 42, 44.
Lankrigg, 72.
Law, The, 105.
Lawrence Hill, 38, 44.
Lebotwood coalfield, 29, 30, 32.
Lee, G. W., 31, 83, 90, 91, 108, 113, 120, 123.
Leeds, 32.
Leeds Fireclay Co., 58.
Leeming, 50.
Leeming Reservoir, 55.
Lees, 61.
Lees, Mr., 60.
Leicestershire, maps, 29.
Lethanhill, 94.
Leventhorp Hall, 57.
Lever Park, 69.
Lewes memoir, 3, 10, 17.
Lewis, H. P., 123.
Library additions, 126.
Lichfield sheet, 32.
Lightmoor, 43, 44.
Lilburn Burn, 82, 87.
Lilleshall, 40.
Limefield, 106.
Lincoln Hill, 38, 40, 43.
Lindley, 50.
Lindley Moor, 48.
Lindsayston Burn, 90.
Linley, 38, 41.
Linley Brook, 38.
Linlithgowshire, maps, 30.
Linstock, 76, 80.
Lipley, 44.
Little Law, 100, 101.
Little Sowdley, 44.

Digitized by Google

Little Town, 37.
Little Wenlock, 38, 39, 43, 44.
Littleworth, 44.
Liverpool memoir, 32.
Lloyd, W., 17, 59.
Lloyd's Coppice, 43.
Loamhole Dingle, 38.
Loamhole Pool, 39.
Loch Gelly, 112.
Loch Martnaham, 90, 91, 93, 94.
Loch Sail an Ruathair, 117.
Lochgelly, 112, 113.
Lochgelly coalfield, 31.
Lochlyoch, 102.
Lochore, 114.
London and South-Eastern district, 9, 16, 28, 33, 34–37.
London basin, borings in, 127–137.
London, North, map and memoir, 9, 12, 17, 18, 19, 34.
Longframlington, 88.
Longhill Point, 94.
Longhorsley, 86, 87.
Longstaff, Mrs. Jane, 123.
Longtown, map and memoir, 13, 17.
Longwood Edge, 48.
Longworth Clough, 66.
Lorbottle, 83.
Lordsfield Pit, 63.
Lothian, East, 29.
Loudon Hill, 105.
Low Moor Iron Co., 51.
Lower Ennerdale, 70.
Loweswater, 70.
Lowther Park, 72.
Luton, boring at, 134, 135.
Luzley Brows, 61.
Lydebrook Dingle, 39, 43.
Lymeside, 62.

MacGregor, A. G., 19, 21, 89, 90, 93, 94, 95.
Macgregor, M., 7, 14, 96–107.
Macnair, P., 109, 111, 124.
Madeley, 38, 43.
Maden, J., 17, 81, 83, 87, 88.
Maidengill, 104.
Mainshill Wood, 104.
Malcolm, G. W., 24.
Maltby Colliery, 121.
Man, Isle of, 34.
Manchester, 17, 31, 59, 60, 64, 65.
Manson, W., 22, 91, 97, 105, 124.
Maps published, 17, 20.
Marchglen Pit, 140.
Market Drayton, 38, 41, 42.
Marlborough, map and memoir, 10, 16, 17, 18, 19, 34, 36–37.
Marsden, 46.
Marsh Hill, boring at, 121, 136.
Marshall, P., 24.
Maryport sheet, 17, 70, 74.
Mascall, G. S., 24.
Massey, W., 127.
Matley, C. A., 22, 25.
Matthews, T., Ltd., 58.
Mauchline, 92, 94, 138.
Maybole, 89.
McLintock, W. F. P., 125, 126.
Medlock Valley, 65.
Meece Brook, 45.
Meek, J. B. L., 60.
Meikleholm Glen, 90.
Memoirs published, 17, 21.
Memoirs, typography, covers and style, 2.
Mere Burn, 84, 85.
Merrow, 35.
Merry Dale Clough, 46.
Mersey, River, 65.
Middleton Moor, South, 82, 87.
Middleton, Old, 82.
Midgeholme, 76, 77, 78.
Midland District, 16, 28, 33, 34, 38–45.
Midlothian, 29, 31, 101, 109, 142.
Mill Beck, 78.
Mineral Resources, Special Reports on, 3, 9, 13, 15, 17, 19, 22, 23, 34, 119, 125.
Mining Association exhibit, 23, 125.
Mockerkin Tarn, 72.
Moffat sheet, 15.
Mole Valley, 36.
Monk's Water, 103.
Monmouthshire, maps, 29.
Moore, W., 127.
Moors, The, 39.
Morley, 52, 53.
Morley Main, 52.
Morpeth sheet, 13, 17, 31.
Morton, Joseph, and Co., 58.
Mosley, C., 58.
Moss Dalts, 71, 75.
Mosser, 71.
Mossley Cross, 61.
M'Tuga Mine, Proprietors of, 25.
Much Wenlock, 39.
Muff, H. B., 55.
Muirfoot, 106.
Muirkirk, 14, 31, 92, 104, 124.
Muir-Wood, Miss H. M., 120.
Mull, map and memoirs, 13, 20, 21.
Mull, Ross of, 116.
Murray, G. W., 25.
Museum of Practical Geology, closed, 4; New building at South Kensington, 4, 16; Piccadilly entrance, 15, 23, 126.

Digitized by Google

Naden Valley, 61.
Naworth Castle, 76.
Netherwitton, 87.
New Amianthus Mines, Proprietors of, 25.
New Cumnock, 89, 94, 95.
New Dailly, 90.
New Field Clough, 69.-
New Inn Bank, 42, 44.
New Zealand Exhibit, 23, 25.
Newbiggin Burn, 83.
Newburgh Pit, 86.
Newcastle-on-Tyne, 13, 17, 31, 81, 87.
Newport (Salop), 38.
Newton, 96, 100, 106.
Newtown, 82.
Nil-Desperandum Mine, Proprietors of, 25.
Norham, map and memoir, 13, 17, 18.
Normandy Common, 35.
North Ayrshire, 29, 33.
North Dean Wood, 48.
North London, 9, 12, 17, 18, 19, 34.
North Wales, 32, 34.
Northumberland, 28, 29, 30, 31, 81–88, 116.
Nottinghamshire, maps, 29, 30, 31.
Nutberry Hill, 96, 103.

Oak Colliery, 63.
Oatlands Colliery, 74.
Ockham, 36.
Offleyhay, 44.
Oil Shales of the Lothians, 15, 20.
Old Allan Moor, 56.
Old Dolphin, 51.
Old Middleton, 82.
Old Red Sandstone, 89, 99–104, 137.
Oldham, 59, 60, 61, 62.
Oldsprings, 41.
Ordovician Rocks, 70–72, 96–97, 123.
Orrell Moss, 65.
Oswestry, 32.
Ottershaw boring, 129.
Oxenhope, 55.
Oxenhope Valley, 55.
Oxford memoir, new edition, 10, 17, 22, 121.
Oykell, River, 117.

Pagie Hill, 106.
Palæontological Work, 2, 22, 120–124.
Pap Craig, 102, 103.
Papcastle, 72.
Parkhall Burn, 104.
Pathhead, 90, 113.
Patna, 89, 90, 91, 92, 93, 94, 95.
Paul Clough, 55.
Peach, B. N., 15, 29, 97, 99, 103.
Pembrokeshire, maps, 30.
Pennine Fault, 79.
Pennines, 46.
Penrose, J. D., 25.
Pentland Hills, 100, 101.
Permian Rocks, 65.
Petrographical Work, 2, 21, 116.
Pettinain, 96, 102.
Pettycur, 109.
Pewley Hill, 34.
Phemister, J., 14, 19, 21, 96, 103, 104, 105, 106, 116.
Phillips, J., 121.
Photographic Work, 23.
Piedboeuf, Paul, 25.
Pirton boring, 134, 135.
Pitch Place, 35.
Pitkinny, 113, 114.
Pitty Beck, 57.
Pitty Beck Valley, 57.
Plean, 108.
Pleistocene and Recent, 35, 36, 43–45, 53–58, 65, 75–76, 79–80, 87–88, 134.
Pocock, R. W., 10, 11, 16, 38, 39, 43.
Ponfeigh Burn, 106.
Poniel Water, 103, 105.
Popham, J. L., 25.
Posenhall, 44.
Pratt, J. F., 23, 119.
Preston, 17, 59.
Pringle, J., 10, 22, 25, 120, 121, 127–137.
Professional Assistance outside the Survey, 3.
Programme for 1925, 5.
Publications, 17, 20, 21.
Pule Hill, 46, 47.
Pyrford, 35.

Que Que Lime Works, Ltd., Proprietors of, 25.
Queensbury, 49.
Quothquan Law, 100.

Radley, E. G., 117, 118.
Rainham, boring at, 134.
Rake Bank, 48.
Ramsbottom, 67.
Rastall, R. H., 71.
Read, H. H., 14, 19, 21, 96, 103, 104, 106, 116.
Redhill, 34.
Refractory materials, Special Report on, 17, 18.
Renfrewshire, 30, 93.
Retford, 31.
Rhodes, J., 9, 23.
Rhodesian Chrome Mines, Ltd., Proprietors of, 25.

Digitized by Google

Richardson, L., 25.
Richardson, W. A., 25.
Richey, J. E., 19, 21, 89, 90, 91, 93, 116, 124.
Rigfoot Pit, 95.
Ripley, 36.
Rishworth, 46.
Rivington Moor, 68.
Rivington Pike, 68, 69.
Roads, cutting of new, 4, 9, 34.
Roberton, 96, 100.
Roberton Burn, 100.
Roberton Law, 96.
Robertson, T., 11, 16, 38, 41, 44, 45.
Rochdale, map and memoir, 11, 17, 31, 61, 65–69.
Rochester, boring at, 134, 135.
Roddam Dene Burn, 87.
Roddlesworth, River, 66.
Roeder, Carl, 60, 64.
Roman Fell, 77.
Romford, map and memoir, 9, 17, 18, 34.
Roscobie Hills, 109.
Ross, G., 19, 96, 103, 105, 106.
Ross of Mull, 116.
Rossendale Anticline, 59.
Ross-shire, 117.
Rothbury sheet, 13, 17, 81, 83, 88.
Rough Castles, 82.
Rowrah, 72.
Russell, R., 75.
Rutherfurd, W. G., 25.
Ryburn valley, 47.
Rye Water, 124.

Saffron Walden, 137.
St. Bees, 80.
St. Helens, 74.
Sale, 65.
Salendine Nook, 49.
Saline, 15, 112, 114.
Saline Hills, 108, 114.
Salterhebble, 49.
Sambrook, 42.
Sandford, K. S., 10.
Sanquhar coalfield, 29, 30, 31, 138.
Scaur Hill, 102, 104.
Scaut Hill, 102.
Scholes, 51.
School Green, 57.
Scotchman's Post, 68.
Scotland, Central Coalfield of, 14, 19, 21, 96, 113, 142.
Scottish Erratics, 80.
Scremerston coalfield, 31.
Seafield Tower, 109, 110, 111, 112.
Selby's Cove, 83, 88.
Send Heath, 36.
Sentry Hill, 55.
Severn Barrage scheme, 16.
Severn gorge, 44.
Severn, River, 41.
Severn Valley, 43.
Shamva Mines, Ltd, Proprietors of, 25.
Sharp Knott, 70.
Shaw Wood, 69.
Sheets Heath, 35.
Sheffield, 31.
Sherlock, R. L., 17, 59.
Shibden Dale, 50.
Shiel Burn, 103, 105.
Shirlett Hill, 38.
Shotover, 120.
Shrewsbury Coalfield, 29, 30, 32.
Shrewsbury Sheet, 11, 16, 32, 38.
Shropshire Union Canal, 41.
Siddow Fold, 67.
Silloth, map and memoir, 13, 17, 18.
Silurian Rocks, 38–39, 97–99, 123.
Simmerson Hill, 76, 77.
Simonside Fells, 83, 88.
Simpson, J. B., 19, 89, 94, 95.
Six-inch topographical maps, quarter sheets, 3.
Skiddaw, 71.
Slaithwaite, 46, 47, 53.
Slindon, 45.
Smaithwaite, 71.
Smith, B., 12, 17, 31, 70–80.
Smith, John, 89.
Smith, W. Campbell, 25.
Smithies, 52.
Smithills Moor, 67.
Smithy Burn, 103.
Smythe, J. A., 88.
Soil Hill, 50.
Sollas, W. J., 10.
Somersetshire, Water Supply memoir, 17.
Sorn, 92.
South Ayrshire, 29.
South Cartington, 88.
South Gosforth, 87.
South Middleton Moor, 82, 87.
South Pitkinny, 113.
South Staffordshire Coalfield, 10, 27, 29, 32, 33.
Southall, 136.
Southcraig, 93, 94.
Southend Water Company, 132.
Southern Upland Fault, 96.
Sow, River, 42, 44, 45.
Sow valley, 45.
Sowdley, Great, 42.
Sowdley, Little, 44.
Spath, L. F., 34, 122, 130.
Spen valley, 55.
Spence, Peter, and Sons, Ltd., 25.

Digitized by Google

Springhill, 124.
Staffa memoir, 13, 20.
Stafford sheet, 11, 16, 32, 38, 41, 45.
Staffordlake, 35.
Staffordshire coalfields, 10, 27, 29, 30, 32, 33.
Stainland, 48.
Stalybridge, 60, 61.
Standing Hill, 35.
Standon, 42.
Staveley Coal and Iron Co., Ltd., 25.
Steelend, 112.
Steeraway, 39, 40.
Stephens, J. V., 16, 46, 49, 50, 51, 53.
Stirlingshire, 14, 19, 20, 29, 30, 31, 108, 113.
Stoke-on-Trent, map and memoir, 10, 17, 32.
Stonehill, 99.
Stopes, Miss M. C., 60, 61.
Stornoway, 119.
Strachan, W. E. J., 22, 97.
Strahan, Sir A., 28.
Strath Oykell, map and memoir, 14, 19, 21.
Strathaven district, 96–107.
Stream Head, 55, 56, 57.
Stubden Beck, 50.
Stubden Reservoir, 56.
Stublick Fault, 78, 79.
Surprise Hill, 35.
Sutcliffe, R., 117–119.
Sutherlandshire, 117.
Sutton Place, 35, 36.
Swaites, 99, 100.
Swarth Fell, 72.
Swindon, 37, 120.
Symon Fault, 40, 41.

Tait, D., 22.
Talkin Fell, 78.
Tame, River, 60, 62.
Tameside Mills, 60.
Tarnmonath Fell, 76.
Tate, G., 82.
Teall, Lady, 7, 23, 126.
Teall, Sir J. J. H., 1, 7, 23, 126.
Templeman, A., 71.
Tertiary Rocks, 34, 35, 122, 127, 129–132, 133.
Thames valley, 136.
Thames valley near Goring, Guide to, 19.
Thankerton, 100.
Thomas, H. H., 21, 116.
Thomas, Ivor, 120.
Thornton, 50, 57.
Thornton Hall, 57.
Thornton Heights Ridge, 57.
Thornton Moor Reservoir, 49.
Tickwood, 39.
Tindale Tarn, 77.
Tinto district, 96–107.
Tinto End, 102.
Tinto Hills, 101, 102.
Tiree, map and memoir, 14, 20, 116.
Tockholes, 68.
Tockholes Plantation, 67.
Tongue Glen, 94.
Tongue How, 72.
Tonks, L. H., 17, 59, 60, 64.
Topley, W , 86.
Torryburn, 112.
Tosson, Great, 82.
Transvaal Platinum Mines, Proprietors of, 25.
Triassic Rocks, 42, 65, 79.
Trotter, F. M., 17, 70, 76, 79, 80.
Trough Lane, 55.
Tuckies, 44.
Turriff memoir, 13, 20.
Tyne, River, 81, 84, 85, 86, 87.
Tyrrell, G. W., 95, 103.

Ulldale, 75.
Underground deposits, methods of detection, 3.
Upper Batley, 52.
Upper Birstal, 52.
Upper Stubden Dale, 51.

Valleyfield, 112.
Virginia Water, boring at, 22, 127–132, 136.

Wakefield Corporation Water Works, 58.
Wales, North, 32, 34.
Wales, South, 28, 29.
Walker, 87.
Walker Fold, 69.
Wallnook, 77.
Wankie Colliery Co., Ltd., 25.
Ward, C., 71.
Ward's Reservoir, 67.
Warkworth, 81.
Warley Common (Yorks.), 48.
Warwickshire, maps, 29, 30, 32.
Waterside, 93, 94.
Wath Bridge, 71.
Watson, D. M. S., 60, 61.
Wedd, C. B., 38.
Wedder Law, 104, 105, 106.
Wellington (Salop), 38, 39.
Wem, map and memoir, 10, 17, 19.
Wembley Exhibition, 4, 22, 23, 121, 125.
Wemyss, 138.
Wenlock, Little, 38, 39, 43, 44.
Wenlock, Much, 39.

Digitized by Google

West Chevington, 87.
West Didsbury, 65.
West End Colliery, 52.
Westmorland, maps, 30.
Wey, River, 36.
Whamoss Rigg, 77.
Wheatley, 48, 120.
Whinnah, 71.
Whinny Hill, 50, 55.
Whitaker, W., 8.
White Coppice, 69.
White, H. J. Osborne, 3, 9, 10, 34.
Whitehaven sheet, 12, 17, 29, 31, 70–76.
Whitehead, T. H., 11, 16, 38, 41, 42, 44, 45.
Whitescut Colliery, 78.
Whitfield Burn, 82.
Whittakers Pit, 63.
Whittingham Wood, 82.
Wholestone Moor, 47.
Wibsey, 55.
Wildshaw Hill, 96.
Willey, 38, 39, 44.
Willey Green, 35, 36.
Willowmoor, 38, 39, 44.
Wills, L. J., 43, 44.
Wilson, G. V., 12, 17, 32, 46.
Wilton, 76.
Wilton Fell, 72.
Wiltshire, Water Supply Memoir, 3, 8, 17.
Windmill Hill, 37.
Windrow Burn, 103, 107.
Windrow Hill, 103.
Windsor, 136.
Winkfield boring, 129.
Winter Hill, 67, 69.
Wisley, 36.
Wiston, 100.
Withington, 65.
Withnell Moor, 66.
Wollaston, T. C., 25.
Wolverhampton sheet, 11, 16, 32, 38.
Wood Park Colliery, 63.
Woodhall, 82.
Woodhead, T. W., 53, 58.
Woodstreet, 35.
Woodwall Green, 42.
Wooler, 81, 87, 88.
Workington, 70, 75.
Worplesdon, 35.
Worth Valley, 55.
Worthing, map and memoir, 9, 17, 19.
Wray, D. A., 16, 46, 49, 50, 53.
Wrekin district, 40.
Wrekin, The, 38, 44.
Wrexham, map and memoir, 10, 17, 29, 32.
Wright, J., 111.
Wright, W. B., 11, 17, 31, 59–69.
Wroughton, 37.
Wyke, 35, 44.
Wyre, Forest of, 29, 30, 32.
Wythemoor Colliery, 74.

York district office, 2, 9, 11, 32, 46.
Yorks. and Notts. Concealed Coalfield memoir, 12, 17, 27, 32, 33, 46.
Yorkshire, 16, 28, 29, 30, 31, 32, 45–58, 59, 72.

Digitized by Google

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

	s.	d.
VOL. I. TUNGSTEN AND MANGANESE ORES. By Henry Dewey and H. G. Dines, A.R.S.M., A.M.Inst.C.E., with contributions by C. N. Bromehead, B.A., T. Eastwood, A.R.C.S., G. V. Wilson, B.Sc., and R. W. Pocock, B.Sc. 83 pp., 3 illustrations. Wrapper. (1915; Edit. 3, 1923)	2	0
VOL. II. BARYTES AND WITHERITE. By G. V. Wilson, B.Sc., T. Eastwood, A.R.C.S., R. W. Pocock, B.Sc., D. A. Wray, M.Sc., and T. Robertson, B.Sc., with contributions by H. G. Dines, A.R.S.M. 119 pp. 6 plates. 1 text figure. Wrapper. (1915; Edit. 3, 1922)	3	0
VOL. III. GYPSUM AND ANHYDRITE. By R. L. Sherlock, D.Sc., and B. Smith, M.A.; AND CELESTINE AND STRONTIANITE. By R. L. Sherlock, D.Sc. 64 pp. 4 illustrations. Wrapper. (1915; Edit. 2, 1918)	2	0
VOL. IV. FLUORSPAR. By R. G. Carruthers and R. W. Pocock, B.Sc., with contributions by D. A. Wray, M.Sc., H. Dewey, and C. E. N. Bromehead, B.A. 42 pp. 1 illustration. Wrapper. (1916; Edit. 3, 1922)	1	6
VOL. V. POTASH-FELSPAR, PHOSPHATE OF LIME, ALUM SHALES, PLUMBAGO OR GRAPHITE, MOLYBDENITE, CHROMITE, TALC AND STEATITE (SOAPSTONE, SOAP-ROCK AND POTSTONE), DIATOMITE. By A. Strahan, Sc.D., LL.D., F.R.S.; J. S. Flett, D.Sc., LL.D., F.R.S.; and C. H. Dinham, B.A., with contributions by C. T. Clough, M.A.; T. Eastwood, A.R.C.S.; and A. F. Hallimond, B.A. 43 pp. 3 illustrations. Wrapper. (1916; Edit. 2, 1917)	1	0
VOL. VI. REFRACTORY MATERIALS: GANISTER AND SILICA-ROCK, SAND FOR OPEN-HEARTH STEEL FURNACES, DOLOMITE. RESOURCES AND GEOLOGY. 241 pp. 3 plates. 8 text figures. Wrapper. . . . . (1918; Edit. 2, 1920)	7	6
VOL. VII. MINERAL OIL, KIMMERIDGE OIL SHALE, LIGNITES, JETS, CANNEL COALS, NATURAL GAS. ENGLAND and WALES. By Sir A. Strahan, K.B.E., Sc.D., LL.D., F.R.S., with contributions by W. Gibson, D.Sc., H. Dewey, B. Smith, M.A., C. E. N. Bromehead, B.A., and J. Pringle. 125 pp. 1 plate. 7 text figures. Wrapper. . . . . (1918; Edit. 2, 1920)	5	0
VOL. VIII. IRON ORES: HÆMATITES OF WEST CUMBERLAND, LANCASHIRE AND THE LAKE DISTRICT. By B. Smith, M.A., Sc.D. 236 pp. 5 plates. 31 text figures. Wrapper. (1919; Edit. 2, 1924)	5	0
VOL. IX. IRON ORES (*contd.*). SUNDRY UNBEDDED ORES OF DURHAM, EAST CUMBERLAND, NORTH WALES, DERBYSHIRE, THE ISLE OF MAN, BRISTOL DISTRICT AND SOMERSET, DEVON AND CORNWALL. By T. C. Cantrill, B.Sc., R. L. Sherlock, D.Sc., and H. Dewey. 87 pp. 7 text figures. Wrapper . . (1919)	3	6
VOL. X. IRON ORES (*contd.*). THE HÆMATITES OF THE FOREST OF DEAN AND SOUTH WALES. By T. F. Sibly, D.Sc. 93 pp. 14 text figures. Wrapper . . . . . (1919)	4	0
VOL. XI. IRON ORES (*contd.*). THE IRON ORES OF SCOTLAND. By M. Macgregor, B.Sc., G. W. Lee, D.Sc., G. V. Wilson, B.Sc.; with contributions by T. Robertson, B.Sc., and J. S. Flett, F.R.S. 240 pp. 18 text figures . . . . . (1920)	10	0
VOL. XII. IRON ORES (*contd.*). BEDDED ORES OF THE LIAS, OOLITES AND LATER FORMATIONS IN ENGLAND. By G. W. Lamplugh, F.R.S., C. B. Wedd, B.A., and J. Pringle. 240 pp. 8 plates. 12 text figures. Wrapper . . . . (1920)	12	6

Digitized by Google

	s.	d.
VOL. XIII. IRON ORES (*contd.*). PRE-CARBONIFEROUS AND CARBONIFEROUS BEDDED ORES OF ENGLAND AND WALES. By Sir A. Strahan, K.B.E., Sc.D., LL.D., F.R.S.; W. Gibson, D.Sc.; T. C. Cantrill, B.Sc.; R. L. Sherlock, D.Sc., and Henry Dewey. 123 pp. 3 plates. 10 text figures. Wrapper . . (1920)	7	6
VOL. XIV. REFRACTORY MATERIALS: FIRECLAYS. RESOURCES AND GEOLOGY. 243 pp. 4 plates. 13 text figures. Wrapper (1920)	8	0
VOL. XV. ARSENIC AND ANTIMONY ORES. By Henry Dewey, with contributions by J. S. Flett, O.B.E., LL.D., D.Sc., F.R.S., and G. V. Wilson, B.Sc. 59 pp. 1 plate. 2 text figures. Wrapper (1920)	3	0
VOL. XVI. REFRACTORY MATERIALS: GANISTER AND SILICA-ROCK, SAND FOR OPEN-HEARTH STEEL FURNACES, DOLOMITE. PETROGRAPHY AND CHEMISTRY. By Herbert H. Thomas, M.A., Sc.D., A. F. Hallimond, M.A., and Ernest G. Radley. 115 pp. 7 plates. 6 text figures. Wrapper . . . . . (1920)	5	0
VOL. XVII. THE LEAD, ZINC, COPPER AND NICKEL ORES OF SCOTLAND. By G. V. Wilson, B.Sc., with contributions by John S. Flett, LL.D., F.R.S. 159 pp. 2 plates. 16 text figures (1921)	7	6
VOL. XVIII. ROCK-SALT AND BRINE. By R. L. Sherlock, D.Sc. 123 pp. 2 plates. 16 text figures. Wrapper . . (1921)	5	0
VOL. XIX. LEAD AND ZINC ORES IN THE CARBONIFEROUS ROCKS OF NORTH WALES. By Bernard Smith, M.A. 162 pp. 3 plates. 25 text figures. Wrapper . . . . . (1921)	5	6
VOL. XX. LEAD AND ZINC: THE MINING DISTRICT OF NORTH CARDIGANSHIRE AND WEST MONTGOMERYSHIRE. By O. T. Jones, M.A., D.Sc., Professor of Geology and Mineralogy, Victoria University, Manchester. 207 pp. Coloured Geological Map. 27 plates. 4 text figures. Wrapper . . . . (1922)	7	0
VOL. XXI. LEAD, SILVER-LEAD, AND ZINC ORES OF CORNWALL, DEVON AND SOMERSET. By Henry Dewey. 72 pp. 4 plates. 14 text figures. Wrapper . . . . . (1921)	2	6
VOL. XXII. LEAD AND ZINC ORES OF THE LAKE DISTRICT. By T. Eastwood, A.R.C.S. 56 pp. 1 plate. 4 text figures. Wrapper (1921)	2	0
VOL. XXIII. LEAD AND ZINC ORES IN THE PRE-CARBONIFEROUS ROCKS OF WEST SHROPSHIRE AND NORTH WALES. Part I.—WEST SHROPSHIRE. By Bernard Smith, M.A. Part II.—NORTH WALES. By Henry Dewey and Bernard Smith, M.A. 95 pp. 13 text figures. Wrapper . . . . . (1922)	3	0
VOL. XXIV. CANNEL COALS, LIGNITE AND MINERAL OIL IN SCOTLAND. By W. Gibson, D.Sc., from contributions by J. S. Flett, F.R.S., E. M. Anderson, M.A., G. W. Lee, D.Sc., and M. Macgregor, M.A. 73 pp. 6 text figures. Wrapper . (1922)	2	0
VOL. XXV. LEAD AND ZINC ORES OF NORTHUMBERLAND AND ALSTON MOOR. By Stanley Smith, M.A., D. Sc., with contributions by R. G. Carruthers. 110 pp. 15 plates. Wrapper. . (1923)	3	6
VOL. XXVI. LEAD AND ZINC ORES OF DURHAM, YORKSHIRE AND DERBYSHIRE, WITH NOTES ON THE ISLE OF MAN. By R. G. Carruthers and Sir Aubrey Strahan, K.B.E., F.R.S. 114 pp. 2 plates. 6 text figures. Wrapper . . . . (1923)	3	0
VOL. XXVII. COPPER ORES OF CORNWALL AND DEVON. By Henry Dewey. 76 pp. 4 plates. 13 text figures. Wrapper (1923)	2	6
VOL. XXVIII. REFRACTORY MATERIALS: FIRECLAYS. ANALYSES AND PHYSICAL TESTS. By F. R. Ennos, B.A., B.Sc., A.I.C., and Alexander Scott, M.A., D.Sc. 84 pp. 9 text figures. Wrapper (1924)	3	0

Digitized by Google

s. d.

VOL. XXIX. IRON ORES: BEDDED ORES OF ENGLAND AND WALES. PETROGRAPHY AND CHEMISTRY. By A. F. Hallimond, M.A. With an Appendix by F. R. Ennos, B.A., B.Sc., A.I.C., and R. Sutcliffe, M.A., A.I.C. 139 pp. 8 plates. 3 text figures. Wrapper (1925) 3 0

VOL. XXX. COPPER ORES OF THE MIDLANDS, WALES, THE LAKE DISTRICT AND THE ISLE OF MAN. By Henry Dewey and T. Eastwood, A.R.C.Sc. With contributions by Bernard Smith, M.A., Sc.D., and R. G. Carruthers. 87 pp. 6 plates. Wrapper (1925) 2 0

SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM.

	PRICE.		PRICE.
For 1897 – – –	*Out of print.*	For 1902 – – –	*Out of print.*
,, 1898 – – –	1s. 0d.	,, 1903 – – –	1s. 0d.
,, 1899 – – –	1s. 0d.	,, 1904 – – –	1s. 0d.
,, 1900 – – –	1s. 0d.	,, 1905 – – –	*Out of print.*
,, 1901 – – –	1s. 0d.		

SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

	PRICE.		PRICE.
For 1906 – – –	*Out of print.*	For 1916 – – –	1s. 6d.
,, 1907 – – –	*Out of print.*	,, 1917 – – –	2s. 0d.
,, 1908 – – –	1s. 0d.	,, 1918 – – –	2s. 6d.
,, 1909 – – –	*Out of print.*	,, 1919 – – –	2s. 6d.
,, 1910 – – –	*Out of print.*	,, 1920 – – –	3s. 6d.
,, 1911 – – –	*Out of print.*	,, 1921 – – –	5s. 0d.
,, 1912 – – –	*Out of print.*	,, 1922 – – –	4s. 0d.
,, 1913 – – –	1s. 0d.	,, 1923 – – –	4s. 0d.
,, 1914 – – –	1s. 0d.	,, 1924 – – –	2s. 6d.
,, 1915 – – –	1s. 0d.		

Recent Publications.

MEMOIRS.

s. d.

MONOGRAPH ON THE FOSSIL PLANTS OF THE CARBONIFEROUS ROCKS OF GREAT BRITAIN. By Robert Kidston, LL.D., D.Sc., F.R.S.L. & E., F.G.S.

Part 1, with 22 plates.	109 pp.	Wrapper (1923) – – –	15	0
Part 2, with 25 plates.	88 pp.	Wrapper (1923) – – –	12	6
Part 3, with 21 plates.	76 pp.	Wrapper (1923) – – –	12	6
Part 4, with 23 plates.	102 pp.	Wrapper (1923) – – –	15	0
Part 5, with 31 plates.	146 pp.	Wrapper (1924) – – –	20	0

s. d.

THE GEOLOGY OF THE COUNTRY AROUND WEM. (Explanation of one-inch Sheet 138 England). By R. W. Pocock, B.Sc., and D. A. Wray, M.Sc. With contributions by T. C. Cantrill, B.Sc. 125 pp., 5 plates, 2 text figures. Wrapper – – – – (1925) 3 0

THE GEOLOGY OF THE COUNTRY AROUND HERTFORD. (Explanation of one-inch Sheet 239 England). By R. L. Sherlock, D.Sc., A.R.C.Sc., and R. W. Pocock, B.Sc. With contributions by J. Pringle and C. P. Chatwin. 66 pp., 2 text figures. Wrapper (1924) 1 6

THE GEOLOGY OF NORTH LONDON. (Explanation of one-inch Sheet 256 England). By C. E. N. Bromehead, B.A. With contributions by H. G. Dines, A.R.S.M., A.M.Inst.C.E., and J. Pringle. 63 pp., 1 plate, 1 text figure. Wrapper – – – – (1925) 1 6

THE GEOLOGY OF THE COUNTRY AROUND MARLBOROUGH. (Explanation of one-inch Sheet 266 England). By H. J. Osborne White. 112 pp., 3 plates, 11 text figures. Wrapper – – – (1925) 2 6

Digitized by Google

	s.	d.
THE GEOLOGY OF THE COUNTRY AROUND DARTFORD. (Explanation of one-inch Sheet 271 England). By Henry Dewey, C. E. N. Bromehead, B.A., C. P. Chatwin and H. G. Dines, A.R.S.M. 136 pp., 2 plates, 1 text figure. Wrapper – – – – – (1924)	3	0
TERTIARY AND POST-TERTIARY GEOLOGY OF MULL, LOCH ALINE, AND OBAN. (Explanation of parts of one-inch Sheets 43, 44, 51 and 52 Scotland.) By E. B. Bailey, M.C., B.A.; C. T. Clough, LL.D., M.A.; W. B. Wright, B.A; J. E. Richey, M.C., B.A.; and G. V. Wilson, B.Sc.; with contributions by E. M. Anderson, M.A., B.Sc.; H. B. Maufe, B.A.; G. W. Lee, D.Sc.; B. Lightfoot, M.C., B.A.; T. O. Bosworth, M.A., D.Sc.; and G. A. Burnett, B.Sc.; with Petrology by H. H. Thomas, M.A., Sc.D.; and E. B. Bailey, M.C., B.A.; with Chemical Analyses by E. G. Radley, F.C.S., and F. R. Ennos, B.A., B.Sc., A.I.C., and Palaeobotany by A. C. Seward, M.A., Sc.D., F.R.S.; and R. E. Holttum, M.A. 445 pp., 6 plates, 66 text figures. Cloth – – – – – – (1924)	15	0
THE PRE-TERTIARY GEOLOGY OF MULL, LOCH ALINE AND OBAN. (Being a Description of Parts of one-inch Sheets 35, 43, 44, 45 and 52 Scotland). By G. W. Lee, D.Sc., and E. B. Bailey, M.C., B.A., with contributions by S. S. Buckman and H. H. Thomas, M.A., Sc.D. 140 pp., 2 plates, 13 text figures. Wrapper – – (1925)	4	6

MAPS.

Quarter-inch Scale, England and Wales—

Sheet 20 with 24. (London, Dover, Brighton.) Revised Solid edition – – – – – – – – – – –	3	0

One-inch scale, England and Wales—

Sheet 123 (Stoke-upon-Trent). Revised Drift edition – – –		
Sheet 138 (Wem). Drift edition – – – – – – –		
Sheet 138 (Wem). Solid edition – – – – – – –	each	
Sheet 168 (Birmingham). Drift edition – – – – – –	2	0
Sheet 168 (Birmingham). Solid edition – – – – – –		
Sheet 239 (Hertford). Drift edition – – – – – –		
Sheet 256 (North London). Drift edition – – – – – –		

One-inch scale, Scotland—

Sheet 16 (Moffat) – – – – – – – – – –	3	0

Other Memoirs in Course of Publication.

MONOGRAPH ON THE FOSSIL PLANTS OF THE CARBONIFEROUS ROCKS OF GREAT BRITAIN. Part 6.

THE CONCEALED COALFIELD OF YORKSHIRE AND NOTTINGHAMSHIRE. Second EDITION.

THE WATER SUPPLY OF WILTSHIRE FROM UNDERGROUND SOURCES.

THE GEOLOGY OF THE COUNTRY AROUND BIRMINGHAM. (Explanation of one-inch Sheet 168 England).

THE GEOLOGY OF THE GLASGOW DISTRICT. Revised edition.

THE ECONOMIC GEOLOGY OF THE CENTRAL COALFIELD OF SCOTLAND.
Area V. (Glasgow East, Chryston, Glenboig and Airdrie). Second edition.

THE ECONOMIC GEOLOGY OF THE AYRSHIRE COALFIELDS.
AREA I. (Kilbirnie, Dalry, and Kilmaurs.)
Area II. (Kilmarnock Basin, including Stevenston, Kilwinning and Irvine.)

THE GEOLOGY OF STAFFA, IONA, AND WESTERN MULL. (Explanation of one-inch Sheet 43 Scotland).

THE GEOLOGY OF STRATH OYKELL AND LOWER LOCH SHIN.
(Explanation of one-inch Sheet 102 Scotland.)

THE GEOLOGY OF THE COUNTRY AROUND GOLSPIE. (Explanation of one-inch Sheet 103 Scotland.)

Printed under the authority of HIS MAJESTY'S STATIONERY OFFICE
By Wyman and Sons, Limited, Fetter Lane, E.C. 4.

Digitized by Google

Digitized by Google

14 DAY USE
RETURN TO DESK FROM WHICH BORROWED
EARTH SCIENCES LIBRARY
This book is due on the last date stamped below, or on the date to which renewed.
Renewed books are subject to immediate recall.

LD 21–50*m*-6,'60
(B1321s10)476

General Library
University of California
Berkeley

Digitized by Google

Digitized by Google

LONDON:
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE.

To be purchased directly from H.M. STATIONERY OFFICE at the following addresses:
Adastral House, Kingsway, London, W.C.2, and 28, Abingdon Street, London, S.W.1;
York Street, Manchester; 1, St. Andrew's Crescent, Cardiff;
120, George Street, Edinburgh;
or through any Bookseller;
or from any Agent for the Sale of Ordnance Survey Maps,
or from the Ordnance Survey Office, Southampton.

1925

Digitized by Google